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DETERMINING THE EFFECTS OF THE RATE OF FIRING AND RAPID AND SLOW COOLING ON THE PHYSICAL PROPERTIES OF FIRECLAY REFRACTORIES*

By R. C. Hutchison

ABSTRACT

This investigation determined that the rate of firing, as specified in the standard test for the firing behavior of fireclay refractories, could be reduced without materially affecting the accuracy of the data obtained. The rate of cooling is found to be the cause of variations between test results and laboratory and factory results.

I. Introduction

To determine the effects of the rate of firing and the effects of rapid and slow cooling on the physical properties of fireclay refractories, five clays and two refractory mixes were used: Florida kaolin (washed), Zettlitz kaolin, plastic fire clay, New Jersey fire clay, and H & W plastic fire clay.

Enough pieces were made of each clay and body under test to run four fires on each. The time used in firing in the respective tests was 60, 30, 16, and 8 hours. Besides these four fires, two test brick of each were sent to the Kier Fire Brick Company, at Salina, Pennsylvania, to be fired in a short tunnel kiln.[1]

II. Procedure

(1) Grinding The clays were crushed in a jaw crusher and ground in a disk mill until they passed through a 28-mesh screen and the grog passed through a 20-mesh screen.

(2) Screen Analysis Tyler's $\sqrt{2}$ sieves were used ranging from 28 to 200 meshes per square inch. Samples of clay ranging from 500 to 1000 grams were placed in the top sieve of the series, then the full set was placed on a Ro-Tap for a period of not less than 15 minutes or more than 20 minutes. Material remaining on each pan was collected and weighed to an accuracy of 0.5 gram. The percentage held on each sieve was then recorded.

(3) Test Pieces The screened clay was made up with water to a soft plastic consistency and thoroughly wedged and kneaded by hand. A small auger machine was used to shape a column of clay which conformed with the specifications demanded by the American Ceramic Society, as adopted April 1, 1920.

Note: All volumes, weights, and drying methods carried on in this study were made in accordance with the above specifications.

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* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (Refractories Division). Received February 26, 1932.

Submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Ceramic Engineering, 1932, Pennsylvania State College.

[1] The 60-hour fire approximately duplicated their rate of firing in that kiln.

(4) Firing The 60-hour fire is an approximate duplicate of the firing curve used in the Kier tunnel kiln. The four fires were conducted in the following manner: the 60-, 30-, 16-, and 8-hour fire, *i.e.*, 35°C, 45°C, 90°C, and 230°C per hour, respectively, from the start of the fire until a heat treatment was reached, corresponding to the softening point of the third consecutive cone below that at which the first trial was to be drawn, and 12°C, 20°C, 45°C, and 104°C per hour, respectively, from that point until the end of the fire.

Nine test pieces of each clay were placed in a gas-fired muffle.

Pyrometric cones were placed opposite the piece to be drawn at that temperature of heat treatment. A platinum, platinum-rhodium thermocouple and indicating pyrometer were used for temperature control. The cones used in the test were as follows: 02, 1, 3, 5, 7, 9, 11, 13, and 15. Cone 02 was used as an indicator cone, and the first draw was made when cone 1 was down.

(5) Drawing the Test Pieces One test piece from each sample was removed from the kiln and buried in hot sand. When cone 15 was reached in each fire there were two test pieces of each sample in the kiln. One piece was drawn in the usual manner and cooled in hot sand, while the other test piece was left in the kiln and permitted to cool with the kiln. When cool enough to handle, the test pieces were placed in a desiccator until they had cooled to room temperature. They were then inspected and any adhering particles of sand or other material picked up during firing were removed.

From this point, the investigation was carried on in accordance with the method adopted by the AMERICAN CERAMIC SOCIETY on April 1, 1920.

(6) Data The methods used in calculating the data for this investigation were the same as those specified and adopted by the AMERICAN CERAMIC SOCIETY on April 1, 1920.

III. Summary of Results

The results were tabulated and curves drawn.

Within the limits of this experiment the following inferences may be drawn:

(1) A variation in the rate of firing did not materially affect the physical properties of the refractories under observation.

(2) Pieces which were permitted to cool with the kiln nearly duplicated the physical properties, including color, of those fired in the commercial kiln.

(3) The commercial color was easier to duplicate when the reducing conditions in the final stages of the fire were more severe.

(4) Slow cooling (cooling with the kiln) did not affect the shrinkage, bulk specific gravity, apparent specific gravity, or calculated linear shrinkage.

(5) Slow cooling had a marked effect on the absorption and porosity of pieces that were well vitrified at cone 15.

IV. Conclusion

Results obtained from this investigation were as follows:

(1) Regardless of the rapidity of the rate of firing, it is possible to get an accurate indication of the physical properties of any fire clay or fire-clay body.

(2) The rate of cooling is the actual cause of the variation between tests which are conducted in a commercial kiln and those that are conducted in a laboratory kiln.

(3) It is reasonable to conclude that pieces which are well vitrified when rapidly cooled have a tendency to develop internal strain, causing surface and internal cracks which admit water and hence give a marked increase in the water absorbed.

Acknowledgment This problem was suggested by S. M. Phelps, Senior Fellow, American Refractories Institute, Mellon Institute, Pittsburgh, Pa.

The author wishes to acknowledge his indebtedness to the Kier Fire Brick Company, of Salina, Pa., for the valuable assistance given; to James W. Stewart for his guidance in conducting the screen analysis; to H. F. Graves and to the Ceramic Department, Pennsylvania State College, for the use of laboratories and equipment.

AN INVESTIGATION OF THE ACTION OF COAL-ASH SLAGS ON FIRE BRICK BY MICROSCOPIC METHODS*

By Harold E. Simpson

ABSTRACT

The action of coal-ash slags on firebrick refractories was studied by microscopic examination of thin sections prepared from quenched samples of ash and refractory heated together. The eight refractories used varied as to clays, method of fabrication, grind, and firing treatment. Six different coal ashes varied from highly corrosive to noncorrosive ashes. Samples were quenched at intervals in the range of 2200 to 2800°F and the critical temperature or maximum safe operating temperature of all combinations of slag and refractory was determined. These values are presented together with a discussion of the various minerals formed.

I. Introduction

For the past several years the Special Research Committee on Boiler Furnace Refractories of the American Society of Mechanical Engineers has sponsored an extended investigation of the causes of the failure of boiler-furnace refractories. This investigation has been divided into the following phases:

(1) A study of the refractories service conditions in boiler furnaces by the United States Bureau of Mines. This work has been completed and the results published.[1]

(2) The development of a simulative-service slagging test by the University of Illinois. The description of the method of test and certain results have been published.[2]

(3) The study by microscopic examination of the mineral systems found in coal-ash-firebrick combinations by the Columbus Branch of the Bureau of Standards. This investigation has not yet been completed, but in its course a method of test has been developed for the determination of the temperature above which rapid attack of a given refractory would occur. The method was applied to a number of the coal-ash-refractory combinations of the survey of service conditions and the results have been published.[3]

(4) Trials of the two types of tests on a series of refractories representing the principal types of clays and variations in methods of manufacture.

(5) Trials of certain of the refractories in boiler furnaces to check the test findings.

The present investigation was part of the fourth phase, namely, the application of the microscopic test to determine the temperature above which rapid attack will occur with certain refractories and a series of coal-

* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (Refractories Division). Revised copy received June 3, 1932.

[1] R. A. Sherman, "A Study of Refractory Service Conditions in Boiler Furnaces," U. S. Bur. Mines, *Bull.*, No. 334 (1931).

[2] (*a*) R. K. Hursh, *Trans. A.S.M.E. Fuels & Steam Power*, **51** [22], 339 (1929); (*b*) *ibid.*, **53** [22], 297 (1931).

[3] T. A. Klinefelter and E. P. Rexford, *ibid.*, **53** [22], 301 (1931).

ash slags. The work was undertaken by Battelle Memorial Institute at the request of the Special Research Committee; it was conducted on the endowment funds of the Institute as a part of its program of research on fuels and metallurgy.

II. Method of Investigation

In another paper[4] the author has given a classified review of the various methods that have been used for testing the resistance of refractories to slag; this review shows that the trend of development has been toward better understanding of the mechanism of the attack of slag on refractories. Although the viscosity of the slag, the degree of penetration of slag into the refractory, and abrasion, are important factors in fixing the quantitative destruction of the refractory, yet the reaction between slag and refractory is essentially chemical.

Expressed in terms of the oxides as determined by chemical analysis, fireclay refractories used in boiler furnaces consist essentially of silica and alumina with small amounts of lime, potassium and sodium oxides, and the oxides of iron. Coal ash also consists essentially of silica and alumina, commonly having a ratio within 1.7 to 3, with larger amounts of the fluxes, iron, lime, and the alkalis.

When coal ash is maintained in contact with a refractory at temperatures of the boiler furnace, 2200 to 2800°F, the ash generally softens to a more or less fluid condition. If maintained at a given temperature long enough, an equilibrium for that temperature will be approached at the interface between the ash and the refractory, and certain minerals or combinations of minerals and glasses will be formed. For examination, it is necessary to cool the sample to room temperature, and because the minerals may change on cooling and may vary with the rate of cooling, it is essential to cool the sample quickly; that is, to quench from the temperature being studied.

By examination under the microscope of thin sections made from the sample the minerals formed may be determined, and a repetition at frequent temperature intervals allows the course of the reaction to be determined. At low temperatures the ash is merely sintered and the boundary between the ash and the refractory is distinct; under the microscope the slag shows in a small amount of glass a large amount of crystals, the nature of which will depend on the chemical composition of the ash. As a rule, the solid phases are mullite ($3Al_2O_3 \cdot 2SiO_2$), dehydrated kaolin ($Al_2O_3 \cdot 2SiO_2$), magnetite (Fe_3O_4), feldspar ($RO \cdot Al_2O_3 \cdot xSiO_2$), and quartz ($SiO_2$); occasionally other minerals high in iron, as hercynite ($FeO \cdot Al_2O_3$), fayalite ($2FeO \cdot SiO_2$), and almandite ($3FeO \cdot Al_2O_3 \cdot 3SiO_2$) occur. As the

[4] H. E. Simpson, "A Classified Review of Refractory Slag Tests." See following paper, p. 536.

temperature is increased the solid phases disappear, the content of glass increases, and the slag penetrates the refractory. Solution of refractory starts and finally crystallization of a mineral, generally mullite, radiating out from the refractory is seen.

Klinefelter and Rexford[3] defined the temperature at which the principal solid phase disappeared from the slag and marked penetration occurred, as the "critical temperature" above which rapid corrosion of the refractory could be expected. From the agreement of this temperature as found for a number of slag-refractory combinations and the temperatures of failure reported in the field investigation, they proposed this as a test for the maximum safe operating temperature.

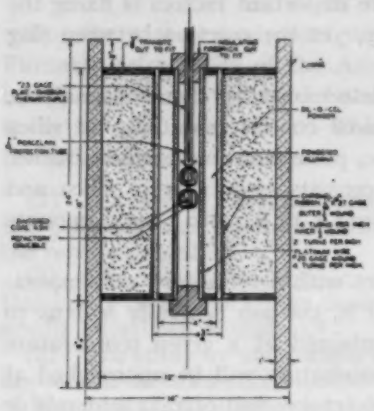

FIG. 1.

The "critical temperature" can be fairly sharply defined for some slag-refractory combinations, but can not be defined for less than a range of 200°F for others. Obviously, the slag and refractory can be operated above their critical range, but rapid deterioration is to be expected.

III. Details of Apparatus and Procedure

Figure 1 shows a cross-section through the vertical furnace which consisted of an inner alundum muffle, $1^1/_2$ inches inside diameter and 16 inches long, wound with 27.5 feet of No. 20 B & S gage wire, 80% platinum, 20% rhodium, and an outer muffle, 4 inches inside diameter, wound with 75.5 feet of 0.1-inch No. 27 B & S gage chromel A ribbon; this was wound more closely at the ends than in the middle to compensate for the greater loss of heat at the ends. The space between the inner and outer muffle was filled with chemically pure powdered alumina. The space between the outer muffle and the 12 inches inside diameter fireclay flue tile that formed the outer shell of the furnace was filled with Sil-O-Cel powder. The furnace was mounted on an iron stand about 2 feet from the floor to facilitate quenching the specimens.

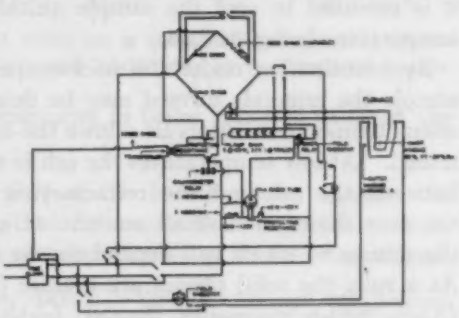

FIG. 2.

Figure 2 shows the wiring diagram of the system by which the temperature of the furnace was automatically regulated. It was a modified Roberts[5] type in which the platinum winding of the furnace was used as one arm of a Wheatstone bridge. The variable arm of the bridge was so adjusted that the galvanometer relay was in balance at the desired temperature of the furnace. A change in temperature of the winding changed its resistance which threw the bridge out of balance. The galvanometer relay controlled the vacuum tube relay which in turn actuated the telegraph relay that cut resistance in and out of the circuit to bring the temperature back to the desired point. A clock-driven contact breaker, as suggested by Cooke and Swallow,[6] in conjunction with a transformer in the galvanometer relay circuit prevented the contacts from sticking. The furnace was operated on 110 volts, direct current. The control apparatus, when properly adjusted, held the furnace constant within about 5°F. Figure 3 shows the set-up of the furnace and control board.

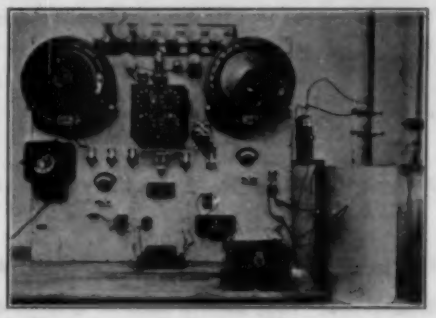

FIG. 3.

IV. Preparation of Specimens

A small crucible, about $^1/_2$ inch in diameter and $^3/_4$ inch deep, was made from a 1-inch cube cut from a standard 9-inch brick. Various methods were used to drill the hole in the refractory, including a drill made of a pointed piece of corundum or periclase forced into the end of a brass tube. The easiest and most rapid method was to use a drill of high-speed steel turned slowly by hand. The crucibles were finally shaped on the outside with a rough silicon-carbide stone.

The crucible was filled with the coal ash that had been previously sintered, placed in a sling of platinum wire, and suspended in the furnace. Two crucibles were normally suspended in the furnace at one time.

The temperature of the furnace was determined by a platinum, platinum-rhodium thermocouple placed above the specimens. A survey of the furnace showed that the temperature was substantially uniform in a zone of about four inches in the center of the furnace.

The crucibles were maintained at the desired temperature 4 to 12 hours and quenched by dropping them in running water. They were broken in half and a thin section of the interface of the slag and refractory was

[5] H. S. Roberts, *Jour. Opt. Soc. Amer.*, **11**, 171 (1925).
[6] E. A. Cooke and J. C. Swallow, *Jour. Sci. Inst.*, **6**, 287 (1929).

prepared. These thin sections were studied under the petrographic microscope.

V. Description of Refractories

Table I shows the variations in the eight refractories prepared for the investigation.

TABLE I

No. of refractory	Clays	Method of fabrication	Grind	Firing treatment (cone number)
ST 1	Dist. No. 1	Dry press	Fine (6-mesh)	6
ST 2	" " "	" "	" "	12
ST 3	" " "	" "	" "	14
ST 4	" " "	" "	Very fine (16-mesh)	12
ST 5	" " "	Stiff mud	Fine (6-mesh)	12
ST 6	" " "	Hand made	" "	12
ST 7	Dist. No. 2	Dry press	" "	12
ST 8	Dist. No. 3	" "	" "	12

The mixes used in the refractories from the three districts were as follows:

Dist. No. 1: 75% smooth flint; 20% semiplastic; 5% fired grog.
Dist. No. 2: 90% smooth flint and semiflint; 10% fired grog.
Dist. No. 3: 80% smooth flint and semiflint; 10% plastic; 10% fired grog.

The slight variations made in the mixes from the different districts conform to works experience and were necessary on account of difference in plasticity and fired strength of the clays.

The brick were made at three plants, one in each of the three districts, especially for the studies being carried on by the A.S.M.E. Committee on Boiler Furnace Refractories.

Table II presents the results of the physical tests for refractories on samples of these brick.

No data were available on the mineralogical constitution of these clays, but Galpin[7] has reported mineralogical data on similar clays in these respective regions, from which the following is extracted:

(1) Dist. No. 1 Smooth Flint Clay The minerals in order of their importance are (1) kaolinite, (2) "hydro-micas," (3) quartz, (4) zircon, (5) tourmaline, (6) rutile, (7) mica. Kaolinite

NOTE: Ross[8] believes that the so-called "hydro-mica" when used as a hydrous aluminum silicate, that is, isomorphous with muscovite, is incorrect. He states, "We have not been able to secure entirely pure samples, but analyses and optical determinations described on page 172 of United States Geological Survey Professional Paper 165, 'The Kaolin Minerals,' indicate that this material contains no more alkalis than the kaolinite with which it is associated. It is therefore evident that this material is not a mica, but another clay mineral." For this reason "the clay mineral that has been described as 'hydro-mica' " is given in quotation marks.

Ross also states that "the complex mineral mixtures, that are called flint clays, probably contain halloysite as well as kaolinite, especially those with much amorphous material."

[7] S. L. Galpin, *Trans. Amer. Ceram. Soc.*, **14**, 301 (1912).
[8] Clarence S. Ross, U. S. Geol. Surv. Private communication.

is by far the most abundant mineral. The hydro-micas are present, but do not show marked development. Quartz is scarce as are also the other minerals.

(2) Dist. No. 1 Semiplastic Clay "Hydro-micas" make up the bulk of the clays along with muscovite and kaolinite. Rutile and tourmaline are fairly abundant. Quartz and zircon occur in small grains, but probably rarely.

TABLE II

PHYSICAL TESTS ON REFRACTORIES

Brand	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8
Clay from Dist. No.	1	1	1	1	1	1	2	3
Process	Dry press	Dry press	Dry press	Dry press	Stiff mud	Hand made	Dry press	Dry press
Grind (approx. mesh)	6	6	6	16	6	6	6	6
Firing (cone)	6	12	14	12	12	12	12	12
Porosity (%) (av. of 3)	22.3	22.1	18.9	21.8	21.0	23.6	19.3	23.6
Density (lb./cu. ft.) (av. of 10)	124	119	122	121	122	115	132	128
Spalling: loss after 10 dips (%) (av. of 5)	0	3.5	32.9	27.7	14.5	*31.0	0	9.1
No. dips before end spalls off	22.0	11.2	6.4	5.5	4.4	*6	20.4	15.2
Reheat test linear change after 1400°C (%) (av. of 3)	+0.58	−0.14	−0.14	−0.25	+0.14	−0.07	−0.3	−0.4
After 1500°C (%) (av. of 3)	+2.05	+0.32	−0.9	−0.35	+1.1	−0.11	−1.4	−1.1
Load test (1350°C, 25/sq. in. subsidence) (%) (av. of 3)	−3.6	−2.8	−1.8	−2.4	−2.0	−1.8	−3.0	−3.9
Pyrometric cone equivalent	All showed either cone 32 or cones 32 to 33. As the difference of 1/3 cone is within the error of observation, individual results are not reported.							

* The behavior of the hand-made brick in the spalling test and load test is out of line compared with the usual test on this type of brick.

(3) Dist. No. 2 Smooth Flint Clay Kaolinite is the most common mineral, although "hydro-micas" are seen as ribs in the kaolinite. Some accessory minerals are present. The clay is free from pyrite, muscovite, and carbonaceous material.

(4) Dist. No. 2 Semi-Flint Clay "Hydro-micas" are the most abundant minerals. No kaolin was identified, but was believed to be present to some extent.

(5) Dist No. 3 Clays These are similar, structurally, to the Dist. No. 2 flint clay; the texture was very fine and identification difficult. Kaolinite was the most abundant mineral and muscovite appeared as minute scales. Very small grains, believed to be gibbsite, were present, but identification was extremely difficult.

VI. Description of Coal Ashes

The samples of ash were prepared by R. K. Hursh, Professor of Ceramic Engineering, University of Illinois, from samples of coal received from the power plants. As the samples contained 3 to 32% combustible matter

as received, they were completely ashed and sintered at 800 to 900°C before use. Table III gives the chemical composition of the ash as determined by M. P. Benoy in the analytical laboratory of Battelle Memorial Institute.

Table IV gives the results of the standard A.S.T.M. cone fusion tests on the coal ashes.

The data given in Tables III and IV show that the ashes covered a wide range of composition and fusibility. The total flux content not including SO_3 varied from 14.4% for the Lowellville ash to 35.9% for the Peoria ash; the SiO_2/Al_2O_3 ratio varied from 1.70 for the Detroit ash to 2.85

TABLE III

COMPOSITION OF COAL ASH (%)

Coal Power Plant	Illinois Peoria	Illinois Chicago	Illinois Cahokia	Pa. anthracite Nanticoke	W. Va. Detroit	Pa. bituminous Lowellville
SiO_2	41.9	42.5	52.6	56.8	49.9	56.9
Al_2O_3	14.7	16.3	24.3	24.0	29.3	28.4
Fe_2O_3	20.3	25.6	13.7	10.9	11.0	10.3
CaO	12.8	6.6	4.2	4.3	4.4	1.3
MgO	0.8	1.1	1.1	1.0	0.9	0.8
SO_3	7.5	4.6	1.7	0.2	1.5	0.3
P_2O_5	0.4	0.3	0.1	0.1	0.3	0.2
Alkalis (by difference)	1.6	3.0	2.3	2.7	2.7	1.8
	100.0	100.0	100.0	100.0	100.0	100.0
SiO_2/Al_2O_3 ratio	2.85	2.61	2.16	2.37	1.70	2.01

TABLE IV

CONE FUSION TESTS OF COAL ASH

Coal ash	Critical Points, °F			Fusion Range, °F		
	Initial deformation	Softening temp.	Fluid temp.	Start to down point or "softening interval"	Down point to fluid or "flowing interval"	Start to fluid or "total fusion interval"
Peoria	1970	2020	2360	50	340	390
Chicago	1990	2060	2400	70	340	410
Cahokia	2100	2160	2500	60	340	400
Nanticoke	2250	2290	2560	40	270	310
Detroit	2240	2350	2620	110	270	380
Lowellville	2360	2470	2750	110	280	390

for the Peoria ash. The CaO content varied from 1.3 to 12.8% and the Fe_2O_3 content from 10.3 to 25.6%; with the exception of the Detroit ash, the ashes stood in the same order of softening temperature as their total flux content.

Duplicate runs were made on all determinations. The "softening temperature" determination checked within 50°F or better, while the "initial deformation" and "fluid temperature" checked within 100°F or better.

VII. Discussion of Results

(A) Mineral Characteristics of Ashes

(1) Peoria Ash The Peoria ash had a low content of SiO_2 and Al_2O_3 and a high content of CaO and Fe_2O_3; consequently, it had a low softening temperature. At 2200°F the glass matrix contained feldspar and had a high content of magnetite and other iron-bearing minerals, one of which was believed to be hercynite ($FeO \cdot Al_2O_3$), as it had a green cast in thin section and a high index of refraction, about 1.80. As the temperature was increased, these minerals went into solution and the glass content increased. At 2500°F the feldspar had gone into solution and the magnetite and hercynite usually preceded it. Hence, by 2500°F the slag was entirely dark brown glass.

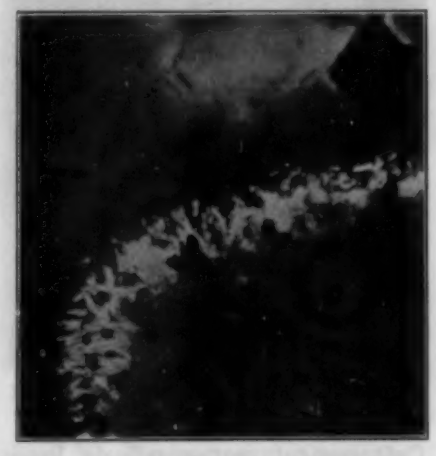

FIG. 4.—Dist. No. 1 refractory (ST1) Peoria ash 2350°F; 200 × (nicols ‖)

FIG. 5.—Dist. No. 1 refractory (ST1) Peoria ash 2375°F; 200 × (nicols ‖)

No outstanding difference in minerals present was noted with the various refractories; only a lighter colored glass appeared to develop with the Dist. No. 2 and Dist. No. 3 refractories.

Figures 4, 5, and 6 show the characteristic action of the Peoria ash. In each figure the refractory is shown in the lower right quadrant, while the slag composes the upper and left quadrants. At 2350°F and 2375°F the slag is largely a light colored glass with considerable magnetite crystals, the large black cubes scattered here and there. The light border between refractory and slag consists of feldspar crystals. At 2350°F and 2375°F very little penetration is seen, but immediately at 2400°F marked

penetration and attack is evident. Large portions of refractory are seen washed out from the face of the refractory and are acting as nuclei for mullite development; the mullite is seen as small needles in Fig. 6. In this particular refractory coal-ash combination sudden attack can be seen and defined over the very short temperature interval of 25°F. The temperature range covered by the three figures is only 50°F. This type of attack was characteristic of the Peoria ash, although it could not always be so closely defined.

FIG. 6.—Dist. No. 1 refractory (ST1) Peoria ash 2400°F; 200 × (nicols ‖)

(2) Chicago Ash The Chicago ash differed from the Peoria ash by only 2% in total flux, but the Fe_2O_3 content was 5% greater, and the CaO content correspondingly lower. The softening temperature was correspondingly low. The minerals present were similar to those in the Peoria ash, except for the greater content of the iron-bearing minerals, as magnetite and hercynite, while the feldspar was less pronounced. The magnetite, hercynite, and feldspar disappeared at 2600°F as compared with 2500° for the Peoria ash. The glass developed was extremely dark in color at 2500 to 2600°F, but became lighter at 2700°F, probably because of solution of refractory.

FIG. 7.—Dist. No. 3 refractory (ST8) Detroit ash 2500°F; 200 × (nicols ‖)

(3) Cahokia Ash The minerals present in the Cahokia slag were fewer than those in the Peoria and Chicago slags over the temperature range studied. At 2300° evidence of fusion could be seen in thin section and at 2400° considerable glass had developed. This ash showed some mullite within the ash itself, along with black magnetite. The magnetite had virtually all disappeared at 2500°F and the mullite from the slag alone at 2600°F. With the Dist. No. 2 and Dist. No. 3

refractories, glass was somewhat slower developing in the slag and the mullite in the slag was slower in going into solution. This may be explained by the greater development of mullite in these refractories.

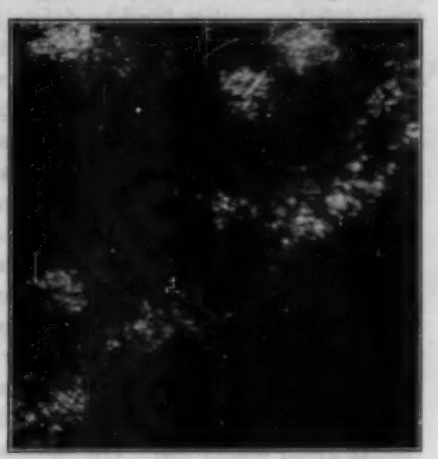

FIG. 8.—Dist. No. 3 refractory (ST8) Detroit ash 2600°F; 200 × (nicols ‖)

(4) Nanticoke Ash The Nanticoke cones for cone fusion deformed quite rapidly, giving an indication of a very definite fusion point. The ash in thin section showed high content of anisotropic materials well disseminated throughout the ash. This anisotropic material contained magnetite, feldspar, mullite, quartz, and occasionally vitreous grains resembling partly fused kaolin. Virtually all of this material had disappeared at 2500°F. With the Dist. No. 2 and Dist. No. 3 refractories, it appeared to go into solution before this. The glass developed was light brown in color, becoming lighter as the temperature was increased.

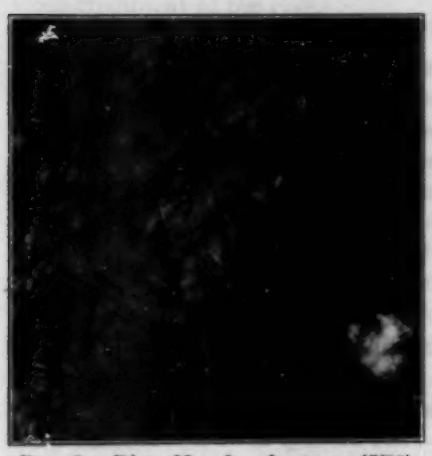

FIG 9.—Dist. No. 3 refractory (ST8) Detroit ash 2700°C; 200 × (nicols ‖)

(5) Detroit Ash The Detroit coal ash merely sintered and did not adhere to the refractories until 2400 to 2500°F, although the character of the refractory seemed to affect this. With higher-fired refractories, cones 12 and 14, as well as the finely ground 16-mesh, the ash did not fuse enough to prepare thin sections until 2500 to 2600°F. The ash showed some anisotropic material, usually mullite and occasionally vitreous masses resembling fused kaolin, that acted as nuclei for mullite development. These disappeared at 2600°F, leaving a light brown glass.

Figures 7, 8, and 9 show the characteristic action of the Detroit ash, to which the Lowellville ash was similar. At 2500°F (Fig. 7) mullite, the needle-like crystals at the upper right, was fairly well developed at the

interface of the refractory and slag. On increase in temperature a gradual penetration and solution of the refractory was noted, making the temperature of failure rather hard to define. This type of slagging was characteristic of the Detroit and Lowellville ashes. It has been pointed out that the Peoria and Cahokia ashes were similar to one another in that they showed action at lower temperatures and the Chicago and Nanticoke ashes represented an intermediate stage between the two extremes. The Chicago ash did show a feldspar development and dark, high iron glass, but the temperature of attack was generally over a greater range than 25 to 50°F.

(6) Lowellville Ash The refractoriness of the Lowellville ash was evident in that no thin sections could be made until 2500°F. At this temperature the slag was composed of a high content of anisotropic material in a dark brown glass matrix. The anisotropic material was primarily mullite which appeared to be developing around vitreous clay or kaolinite material. Occasionally a feldspar crystal or free quartz grain was noted. The ash was low in iron and if any iron-bearing minerals were present they had gone into solution before 2500°F, staining the glass red or brown in color. On increase in temperature the glass content of the ash increased and the anisotropic materials went into solution until at 2700°F the slag was virtually entirely glass.

(B) Mineral Characteristics of Refractories

Although the purpose of this investigation was to determine the range of gradual attack for various refractory and coal-ash mixtures, certain definite and related changes were observed in both the refractory and coal ashes as they were studied over the various temperature ranges.

According to Klein[9] kaolinitic material, on heating, becomes entirely isotropic after its water of combination is driven off; above 1200°C (2192°F) an incipient dissociation began, into two isotropic substances, one of which had an index lower than 1.50 and the other an index higher than 1.60. Between 1400°C (2552°F) and 1450°C (2642°F) sillimanite (mullite) developed. The higher refracting amorphous material previously mentioned Klein believes to be an amorphous phase of sillimanite.

R. E. Somers[10] found similar results in heating various types of clays, except that an isotropic structure did not develop at so low a temperature as Klein found.

Mellor[11] states that crystals of sillimanite (mullite) can develop abun-

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[9] A. A. Klein, "The Constitution and Microstructure of Porcelain," *Trans. Amer. Ceram. Soc.*, **18**, 377 (1916).

[10] R. E. Somers, "High Grade Clays of Eastern United States," U. S. Geol. Surv., *Bull.*, No. 708, p. 292 (1922).

[11] J. W. Mellor, "Can the Firing Temperature of a Body Be Determined from the Microscopic Appearance?" *Trans. Ceram. Soc.* [Eng.], **16** [1], 71 (1917).

dantly in bodies that have not reached 1200°C (2192°F), and he considers the time factor an important conditioning variable.

Ross and Kerr[12] have shown that kaolin is not composed of a single clay mineral, but comprises at least three distinct minerals, namely, kaolinite, dickite, and nacrite. All three minerals conform rather closely to the chemical formula $2H_2O \cdot Al_2O_3 \cdot 2SiO_2$, but show distinctive dehydration curves and break down by loss of water at different temperatures.

Norton[13] also found that time is an important element in the development of mullite in various whiteware bodies and that the formation of mullite crystals in vitrified ware takes place in the feldspar grains.

A similar observation was made on the refractories used in this investigation. First, the hydrous aluminum silicates tend to mat or fuse together to a more or less vitreous groundmass (or matrix) which holds the free quartz.

This vitreous structure at first takes the form of rather large grains; as the temperature is increased, a more uniform vitreous mass appears. Further increase in temperature is accompanied by a slow development of anisotropic material in this formerly vitreous groundmass. This development of anisotropic material is rather slow at first and later develops into rather mature crystals of mullite. This growth and development of mullite varies with the clay used and to a lesser extent with previous treatment of the clay.

The Dist. No. 2 and Dist. No. 3 clays showed an earlier and greater development of this anisotropic groundmass than the Dist. No. 1 clay. This structure had an effect on the degree and type of attack. Wherever this type of groundmass was pronounced, the slag appeared to start at the contact of slag and refractory and to corrode back in a clean even line, instead of penetrating here and there and washing out large portions of the refractory which would later be dissolved. This is shown fairly well in Figs. 7, 8, and 9, where there was a rather even refractory surface during corrosion.

With the highly corrosive ashes, this mullite development in the refractory indicated a greater resistance to attack. This was more pronounced with the Peoria and Cahokia ashes; the Dist. No. 2 and Dist. No. 3 refractories showed to better advantage than did those from the Dist. No. 1 field.

This variation in mullite development was also noticeable in the differently fired refractories. Mullite developed earlier and in greater amount in refractories fired to cones 12 and 14 and a better resistance to the slagging

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[12] C. S. Ross and P. F. Kerr, "The Kaolin Minerals," *Jour. Amer. Ceram. Soc.*, **13** [3], 151 (1930).

[13] C. L. Norton, Jr., "The Influence of Time on the Maturing Temperature of Whiteware Bodies, II," *ibid.*, **14** [3], 192 (1931).

by the more corrosive Peoria, Cahokia, and Chicago ashes was apparent in the cones 12 and 14 over the cone 6 refractories.

A slightly greater mullite development was also noticed in the very

TABLE V

MAXIMUM SAFE OPERATING TEMPERATURE

(°F of Ash and Refractory Combinations)

Refractory	Ash					
	Peoria	Chicago	Cahokia	Nanticoke	Detroit	Lowellville
ST 1 Dist. No. 1 Dry press Fine grind Cone 6	2300–2375	2400–2600	2400–2450	2400–2550	2500–2600	2600–2700
ST 2 Dist. No. 1 Dry press Fine grind Cone 12	2400–2450	2500–2600	2400–2500	2500–2600	2400–2600	2600–2700
ST 3 Dist. No. 1 Dry press Fine grind Cone 14	2450–2500	2500–2600	2500–2600	2500–2600	2500–2600	2600–2700
ST 4 Dist. No. 1 Dry press Very fine grind Cone 12	2500–2550	2500–2600	2400–2500	2500–2700	2600–2700	2600–2700
ST 5 Dist. No. 1 Stiff mud Fine grind Cone 12	2400–2600	2500–2700	2500–2600	2600–2700	2600–2750	2700–2800
ST 6 Dist. No. 1 Hand made Fine grind Cone 12	2400–2500	2500–2600	2400–2500	2500–2600	2500–2600	2600–2700
ST 7 Dist. No. 2 Dry press Fine grind Cone 12	2400–2500	2400–2500	2500–2600	2450–2550	2500–2600	2550–2650
ST 8 Dist. No. 3 Dry press Fine grind Cone 12	2400–2500	2400–2600	2500–2600	2400–2600	2500–2600	2600–2700

fine grind, 16-mesh, over the fine grind, 6-mesh; here again an improvement in the resistance to slagging with the more corrosive Peoria ash was noticed, but no change was seen in the Chicago and Cahokia ashes. It would appear, therefore, that for highly corrosive ashes that show definite

attack around 2350°F it would be highly desirable to use a refractory developing a maximum amount of mullite at these temperatures.

At higher temperatures (2700 to 2800°F), however, the developing of a large amount of mullite in the refractory was not necessarily an indication that it would resist attack well at these temperatures, because the development of mullite increased with increase in temperature and reached a maximum at the temperature of failure. Mullite, highly developed in a refractory at a temperature of 2700 to 2800°F, appeared to be more easily dissipated and dissolved by even a difficultly fusible ash than that moderately developed in a refractory at a temperature of 2400 to 2500°F by a more fusible ash. This may be due to the character of the glass surrounding the mullite crystals, although this supposition has not been confirmed in the present study.

VIII. Summary of Results

Table V shows the complete summary of the "critical temperature range" or the temperature range above which severe corrosion of the refractories would be expected for the forty-eight combinations, as determined by the examination of the slides at successive temperature intervals.

Table V also shows the variation in the "critical temperature range" with the degree of firing of the refractories.

Increase in firing temperature of the refractory increased the resistance to attack of the more highly corrosive ashes, such as the Peoria and Cahokia, that is, cone 12 showed an improvement over cone 6, and cone 14, an improvement over cone 12. The more moderately corrosive ashes, as the Chicago and Nanticoke, attacked the refractory fired at cone 12 less than that fired at cone 6, but further increase in firing temperature to cone 14 did not help.

The more refractory ashes, as the Detroit and Lowellville, were little affected by the use of the higher-fired refractories and with the Detroit ash, cone 12 refractory did not show quite so well as cone 6.

A comparison of the variations in the "critical temperature range" with the fineness of grind of the clays is seen in Table V.

By change of grind from fine, 6-mesh, to very fine, 16-mesh, an improvement was noted with the Peoria, Nanticoke, and Detroit coal ashes. The remaining ashes, Cahokia, Chicago, and Lowellville, showed no improvement. Inasmuch as the first three ashes represent highly corrosive, moderately corrosive, and relatively noncorrosive ashes, all showing an improvement, and the last three also representing highly corrosive, moderately corrosive, and noncorrosive ashes, all showing no improvement, the chances for improvement in resistance to slagging are about equal with increase in fineness of grind of the refractory.

A comparison of the "critical temperature range" with the method of fabrication of the refractories is given in Table V.

With every coal ash, whether highly corrosive or noncorrosive, the stiff-mud brick showed to best advantage. The hand-made brick showed slightly better results than the dry press with the Peoria and the Detroit ash; otherwise they were in exact agreement.

The Dist. No. 2 and Dist. No. 3 clays showed better than the Dist. No. 1 clay with the more corrosive Peoria and Cahokia coal ashes. With the moderately corrosive ashes the Dist. No. 2 and Dist. No. 3 clays were slightly inferior to the Dist. No. 1 clays. With the more refractory ashes the Dist. No. 3 and Dist. No. 1 clays were slightly better than the Dist. No. 2. These differences were very slight and it should be emphasized here that these clays represent only one clay from each district and hence all clays from the districts would not necessarily stand in the same relation.

IX. Conclusions

The following conclusions may be drawn from the data reported:

(1) The test showed certain distinct differences in the "critical temperatures" for the different refractories with a given coal ash. Although the "critical temperature" for all refractories did not stand in the same order for the various ashes, the variations among ashes were greater than among refractories.

(2) Generally speaking, the "critical temperature" varied as would be expected from the chemical composition and fusibility of the ash; that is, it decreased with increasing flux content and with decreasing softening temperature.

(3) With the more easily fusible ashes the "critical temperature" increased with increasing content of mullite in the refractory; it was slightly higher for the refractories from the Dist. No. 3 and Dist. No. 2 than for those from the Dist. No. 1 fields, although, as pointed out, it does not follow that this is necessarily true for all refractories from these districts. The mullite content of the refractories and, hence, the "critical temperature" also increased with the firing temperature of the refractory.

(4) Although the fineness of grind made some difference in the "critical temperature," the results were conflicting and not conclusive.

(5) Refractories made by the stiff-mud process showed a somewhat higher "critical temperature" than those made by the hand-made or dry-press process.

(6) Although with certain combinations of ash and refractory the "critical temperature" could be defined easily within a range of 50°F, it could not be defined for most combinations more closely than 100°F and with some, extended over an even wider range. "A long range indicates that the solution of the refractory starts at the lower end of the range and the rate gradually increases with increase in temperature. Whether the rates of solution at the upper limits of a short and long range will be the same can not be stated."

More work along these lines could well include (*a*) studies similar to

the present in controlled reducing atmospheres, or studies with the iron in the slag having known and various ratios of FeO to Fe_2O_3; (*b*) petrographic determinations of the minerals developed in coal ashes and refractories when separately heated; (*c*) determination of the viscosity of slags; (*d*) further and closer study of the glasses for more accurate identification of their composition; and (*e*) the extension of the study to other refractories, as alumina, silicon-carbide, kaolin, and mullite.

Acknowledgment The work was carried on under the direction of R. A. Sherman, Fuel Engineer, and C. E. Williams, Assistant Director, of the Institute. Special thanks are due to T. A. Klinefelter, Superintendent, and E. P. Rexford, Research Associate for A.S.M.E., of the Columbus Branch of the Bureau of Standards, whose ready coöperation in getting the work under way was invaluable. The author is also indebted to W. J. McCaughey, Professor of Mineralogy, Ohio State University, for aid in petrographic interpretation.

BATTELLE MEMORIAL INSTITUTE
COLUMBUS, OHIO

A CLASSIFIED REVIEW OF REFRACTORY SLAG TESTS*

By Harold E. Simpson

ABSTRACT

The literature on refractory slag tests is reviewed. The various methods are divided into eight different classifications and references to the literature are given.

I. Introduction

A considerable amount of time and money has been expended in the attempt to develop a satisfactory test that will evaluate the ability of refractories to resist slag action. A survey of the literature discloses the wide variety of tests studied.

Note: Because of the desire for brevity and conciseness, detailed descriptions of apparatus and methods are omitted; references to the literature are indicated, however, and further details may be obtained in the original literature.

Ferguson[1] has given a splendid review of the literature on laboratory slag tests for refractories. A similar, yet amplified, classification used by the above author has been adopted in this paper and is believed to include all types of tests. In order to avoid duplication, only those references to the work done subsequent to the above article are given.

II. Measurement of Slag Penetration

Miehr, Kratzert, and Immke[2] amplified the penetration test by taking measurements on the specimen before and after slagging to include (1) the slag solubility number and (2) the slag penetration number. A cylindrical hole was made in the surface of the brick and 50 grams of slag were placed in the hole. The test piece was heated to 100°C above the fusion point of the slag, usually 1200 to 1400°C. The temperature was maintained for one hour. A section was cut through the brick and the progress of solution and penetration noted.

Salmang[3] investigated the action of acid, basic, and neutral synthetic slags on refractory materials. The powdered synthetic slags were placed in crucibles and heated to various temperatures for various lengths of time. After heating, the crucibles were broken in two and the conditions of the slag, penetration or attack on the bonding material of the crucible, and the penetration and attack of the body of the crucible were determined. The results of these studies using twenty-six slags were compared.

This work was continued by Salmang and Schick[4] who found that the order of corrosion of pure oxides on fireclay crucibles was as follows: PbO, FeO, MnO, CaO, Fe_2O_3, K_2O, Na_2O, Mn_2O_3. Mixtures of the oxides had less influence than the pure oxides.

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* Revised copy received June 3, 1932.

[1] R. F. Ferguson, *Jour. Amer. Ceram. Soc.*, **11** [2], 90 (1928).

[2] W. Miehr, J. Kratzert, and H. Immke, *Tonind.-Ztg.*, **51**, 121 (1927); *Ceram. Abs.*, **6** [10], 449 (1927).

[3] Herman Salmang, *Stahl Eisen*, **47**, 1816 (1927); *Ceram. Abs.*, **7** [2], 85 (1928).

[4] Herman Salmang and Friedrich Schick, *Arch. Eisenhüttenwesen*, **2**, 439 (1929); *Ceram. Abs.*, **8** [12], 890 (1929).

Miksch and Salmang[5] extended the work to the action of simple and complex slags on magnesite crucibles. Singly, K_2O, Na_2O, PbO, FeO, Fe_2O_3, MnO, Mn_2O_3, Al_2O_3, SiO_2, and CaS do not attack, while P_2O_5 and B_2O_3 do so strongly. A corroding action was shown only by binary or ternary slags which contained either P_2O_5, B_2O_3, SiO_2, or, to a less extent, Al_2O_3 in excess. The attack of ternary slags is less than binary. Smaller amounts of FeO and CaO in ternary slags cause stronger attack than do larger amounts (the effect of CaO is the greater), while the reverse is true with MnO. That magnesite is less easily slagged than is fire clay is explained by the assumption that it loses its strongly basic characteristic at these temperatures.

Salmang and Schick,[6] in investigating the corrosive power of various synthetic slags, found that oxides of the MO type (M = metal) react as bases, while those of the type M_2O_3 react as acids. The latter oxides do not attack fire clay and check the attack of bases. In silicate fusions Fe_2O_3 is stable up to 1580°, while Mn_2O_3 decomposes at 1500°. The alkali oxides behave as weak acids at these high temperatures, while the alkali-earth oxides act as strong bases. P_2O_5 checks the attack of bases and when present in large amounts in the slag the excess attacks strongly.

Hebestreit[7] measured the penetration of a high lime blast-furnace slag and a high iron slag by means of a planimeter. The refractories used varied over a wide range in Al_2O_3 and SiO_2 content. The slags were pressed into drilled holes made in the brick samples and then fired to 1460°C. The cores from the drilled holes were used for porosity test pieces. The author correlates slag action with the large and small pore space in the refractory. A method for determining the porosity due merely to the large pore spaces and that due to both large and fine pore space is given.

Budnikoff[8] placed powdered slag or glass in cavities made in testing samples. Graphite electrodes were attached to the cavities and the electric current for heating could be regulated so as to maintain the required temperature. This arrangement for testing the stability of the refractories to the action of slag was believed to correspond more exactly with prevailing industrial conditions.

Salmang and Hebestreit[9] later used crucibles of 70 : 30 mixture of fired

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[5] Rudolph Miksch and Herman Salmang, *Arch. Eisenhüttenwesen*, **3**, 313 (1929); *Ceram. Abs.*, **9** [5], 357 (1930).

[6] Herman Salmang and Friedrich Schick, *Arch. Eisenhüttenwesen*, **4**, 299 (1930); *Ceram. Abs.*, **10** [5], 353 (1931).

[7] Otto Hebestreit, "Über die Abhangigkeit der Verschlackung von Schamottesteinen von Flüssmittelgehalt und der Porositat," Dissertation von der Technischen Hochschule, Aachen (1930).

[8] P. P. Budnikoff, *Building Materials*, No. 4, pp. 35–42 (1930); *Feuerfest*, **6** [11], 169 (1930); *Ceram. Abs.*, **10** [4], 274 (1931).

[9] Herman Salmang and Otto Hebestreit, *Feuerfest*, **7**, 1 (1931); *Ceram. Abs.*, **10** [5], 353 (1931).

and unfired kaolin containing either 0.2 or 4% flux and had a porosity of ≈24 vol. %. FeO, as a slag, strongly attacked each type of crucible at 1500°. The action was greatest in the presence of 4% Na_2O or TiO_2. Refractories with 2 or 4% flux were attacked by the various slags only slightly more than those containing none. Tests on commercial brick showed that the action of blast-furnace or open-hearth slag is not directly dependent on porosity. Brick of the same chemical composition and porosity are attacked to the same extent only when the microstructure is the same.

Hyslop and Biggs,[10] in order to maintain a uniform temperature, rotated a crucible built up of four standard-sized fire brick cemented together. The brick were set on end on a 12- by 12- by 4-inch block giving a crucible 6 by 6 by $4\frac{1}{2}$ inches internal dimensions. This crucible is mounted through the bottom of an oil-fired furnace. After receiving a definite heat treatment, a synthetic slag is filled in two charges and the test continued for several hours, or until slag penetrates a joint. The crucible is broken when cold and the test brick removed for examination. One of the results given showed two brick of similar chemical composition but varying greatly in texture. The fine textured material showed deeper penetration.

Salmang and Kaltenbach[11] measured the extent of attack with a standard fireclay crucible on the lower 10 millimeters of the crucible in square centimeters of cross-section after sawing the crucible in two. A formula is developed showing the relation between attack in square centimeters and per cent bases and acids of the slag. It is pointed out that the oxides retain acid or basic character as to their corrosive action in the molten iron silicate slags. Basic character is exhibited by (in order of decreasing strength) CaO, Cu_2O, PbO, BaO, FeO, NiO, and SnO; acid character by Al_2O_3, Fe_2O_3, Sb_2O_5, SiO_2, Ni_2O_3, ZnO, SnO_2, and Cr_2O_3 (in order of increasing acid strength). Generally, R_2O and RO oxides (excepting Zn and the alkali metals) promote corrosion; R_2O_3, RO_2, and R_2O_5 tend to prevent it. The corrosion at 1410°C is about 50% higher than 1320°C, indicating a 50% increased dissociation of the slags to the oxides.

III. The Effect of Ash on the Fusion Point of the Refractory

Nefedieva and Pacukov[12] prepared (3:1, 1:1, 1:3) mixtures of refractory and ash, both sintered and heated in a current of oxygen. The results showed in all cases, except one, a rapid decrease of fusion point

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[10] J. F. Hyslop and H. C. Biggs, *Trans. Ceram. Soc.* [Eng.], **30**, 288 (1931); *Ceram. Abs.*, **10** [12], 844 (1931).

[11] Herman Salmang and J. Kaltenbach, *Feuerfest Ofenbau*, **7**, 161 (1931); *Ceram. Abs.*, **11** [3], 179 (1932).

[12] O. V. Nefedieva and N. B. Pacukov, *Izvestiya Teplotekh. Inst.* [Moscow], **5**, 20 (1929); *Ceram. Abs.*, **8** [12], 894 (1929).

to a 25% ash content, after which the decrease was more gradual and regular.

IV. Quantitative Measure of the Brick Dissolved or Otherwise Removed during a Definite Heat Treatment in Contact with the Slag

Very little work has apparently been done by this method.

Hyslop, Gumm, and Biggs,[13] using a method similar to Coad-Pryor[14] and Rosenhain,[15] studied the effect of corrosion and erosion phenomena on the macrostructure of refractories. Disintegration depends upon two factors, *viz.*, (*a*) the density of the solute-rich layer relative to the solvent, and (*b*) the size of the particles.

If a light upward-flowing layer is formed, the material with large particles is more rapidly broken up than that containing small particles. The reverse holds if a dense downward-flowing layer is formed, the finer the particles the more rapid being the corrosion. In the lead glass, refractory with the larger grog was more corroded than that with the finer, but in a soda-lime glass, the finer material was the more attacked. Hence, fine grog is recommended with lead glass and greater coarse grog with soda-lime glasses.

Nefedieva and Pacukov[16] amplified the following method of Nesbitt and Bell[17] to give quantitative results: A brick sample was weighed and measured and the size of the hollow in one of its sides was determined by means of a volumeter, using pure sand. Its porosity was also determined. The hollow was then filled with ash and slag and the brick with the hollow upward was heated for a known period at a known temperature. After being cooled, weighed, and placed with hollow downward on a fire-resisting crucible to allow any molten ash which might escape to collect in the crucible, it was placed in an oven and kept for the same length of time at the same temperature. After cooling, it was again weighed and measured and from the measurements of the hollow the degree to which the brick was attacked by the given ash sample could be determined.

The authors also include the following physico-chemical processes occurring between the hot slag and refractory materials: (1) penetration of the slag into the pores of the material, in which case the porosity of the refractory and the viscosity of the slag are the most important factors; (2) change in the microstructure of the refractories, the fundamental

[13] J. T. Hyslop, R. Gumm, and H. Biggs, *Jour. Soc. Glass Tech.*, **10**, 405 (1926); *Ceram. Abs.*, **6** [6], 214 (1927).
[14] E. S. Coad-Pryor, *Jour. Soc. Glass Tech.*, **2**, 285 (1918).
[15] Walter Rosenhain, *ibid.*, **3**, 93 (1919).
[16] See footnote No. 12.
[17] C. E. Nesbitt and M. L. Bell, *Proc. A.S.T.M.*, [II] **16**, 350 (1916).

factors of the stage being the temperature of the layer of the material saturated with the slag and the microstructure of the former; (3) destruction of the softened material layer by the molten slag. In this case the quantity of the slag and the temperature are of primary importance.

V. Quantitative Measure of the Brick Dissolved or Otherwise Removed during a Definite Chemical Treatment

Bowmaker[18] developed a quantitative test for testing the durability of glass tank blocks. A definite sized cube (1 by $^1/_2$ by $^1/_2$ inch) was weighed and subjected to the action of a solution containing 3 parts hydrofluoric acid and 2 parts sulphuric acid for 3 hours in a closed leaden vessel provided with a cooled cover. The loss in weight of the test piece served as a measure of the resistance to solubility of the tank block.

Partridge and Biggs[19] used the acid corrosion of Bowmaker[20] to include many different types of glass-house refractories as well as pot-clay mixtures. Glass corrosion tests were also made on the pot-clay mixtures by a crucible and comparison method.

Miehr, with Koch and Kratzert[21] used a similar method with slight variations. They placed an added importance on a solubility figure of the mullite-free portion of the refractory in addition to the solubility factor and resistance factor of Bowmaker. The possibility of standardization is remote in view of the diverse nature of the demands made upon tank blocks.

VI. Qualitative or Quantitative Estimation of the Effect of Impact of Powdered and Molten Slag on the Hot Face of the Refractory

Hursh[22] has applied this method to a rotating cylindrical gas-fired furnace, the test brick making up the walls of the furnace. Powdered slag is fed at a uniform rate through the burner at the top of the furnace and impinges with the blast on the vertical faces of the standard-sized test brick. A record of the volume of the test brick before and after the run, expressed in cubic centimeters loss per square centimeter of exposed face, is an indication of the slagging effect upon the brick. Various temperatures and different furnace atmospheres may be used in the test. The test is believed to duplicate service conditions and may be used as a

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[18] E. J. C. Bowmaker, *Jour. Soc. Glass Tech.*, **13**, 130 (1929); *Ceram. Abs.*, **9** [5], 353 (1930).

[19] J. H. Partridge and H. C. Biggs, *Jour. Soc. Glass Tech.*, **14**, 63 (1930); *Ceram. Abs.*, **9** [9], 743 (1930).

[20] See footnote No. 18.

[21] W. Miehr, *Jour. Soc. Glass Tech.*, **15**, 30 (1931); *Ceram. Abs.*, **10** [8], 576 (1931).

[22] R. K. Hursh, *Trans. A.S.M.E., Fuels & Steam Power*, **51** [22], 339 (1929); *Ceram. Abs.*, **8** [12], 887 (1929).

means of comparing the relative resistance of different types of refractories.

Schaefer[23] used a furnace in which three or four standard blocks were heated by gas to 1600°C in one hour. The slag was poured through the top of the kiln at a speed of 500 grams in 40 minutes. Schaefer emphasized the importance of volatile ingredients entering the pores of the refractory in the vapor state.

Stromberg[24] described a laboratory test furnace using a fuel oil burner and a powdered coal burner to introduce the slag. Thirty standard $2^1/_2$- by $4^1/_2$- by 9-inch brick were built into a test panel and inserted in the wall of the furnace. Forty pounds of ash were fed into the furnace per hour for 48 hours at a temperature of 1350 to 1450°C. The slagging effect was estimated by the amount of brick eroded away, slag penetration, and comparison with the standard brick.

Schaefer and Baumhauer[25] continued the method of sidewise blowing of slag dust on a vertical brick at high temperatures. He tested magnesite and silica brick. Various quantities of slag were used and the depth of penetration was measured. The results of slag penetration versus layer depth in millimeters are given as a measure of the degree of scorification. The quantity, thickness, density, and chemical composition of slag layers are also given.

Hyslop and Biggs,[26] in attempting to develop a quantitative durability slag test, rotated a refractory test piece (9 by 1.5 by 1.5 cm.) in a silit (perhaps SiC) rod furnace. At the requisite temperature flux was charged over the rotating refractory by means of a water-cooled spoon. The time taken for the flux to sever the test piece was taken as a direct measure of the durability of the refractory under the conditions of test.

VII. Estimate of the Change in Chemical Composition of the Slag or of the Brick after a Definite Period of Interaction

Mellor[27] showed by difference in analysis of the fuel ash and the flue-dust slag that this might offer a possible means of determining slag action. Dale[28] has stated, however, that the main experimental difficulty in effecting such a procedure is the problem of finding a containing vessel inert toward slag action.

Wilson[29] studied the effect of ammonium chloride on fire brick and silica

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[23] J. Schaefer, *Tonind.-Ztg.*, **54**, 1223 (1930); *Ceram. Abs.*, **9** [12], 1051 (1930).
[24] B. W. Stromberg, *Chem. Met. Eng.*, **37**, 685 (1930); *Ceram. Abs.*, **10** [2], 123; [8], 574 (1931).
[25] J. Schaefer and F. Baumhauer, *Feuerfest*, **7**, 33 (1931); *Ceram. Abs.*, **10** [8], 576 (1931); *Chem. Abs.*, **25**, 3791 (1931).
[26] J. F. Hyslop and H. C. Biggs, *Refrac. Jour.*, **8** [2], 52 (1932).
[27] J. W. Mellor, *Trans. Ceram. Soc.* [Eng.], **13**, 12 (1913).
[28] A. J. Dale, *ibid.*, **25**, 326 (1925–26).
[29] L. M. Wilson, *ibid.*, **23**, 39 (1923); *Ceram. Abs.*, **3** [10], 288 (1924).

brick. Weighed chips were placed in the furnace and subjected to ammonium chloride gas at various temperatures and time intervals. The results of analyses of representative samples before and after treatment were as follows: At temperatures between 700° and 1200°C, ammonium chloride removes iron and alumina from fire clay, or iron, alumina, and lime from silica brick. Silica brick should have a greater resistance to salty coal in coke ovens than fire brick.

Firth, Hodkin, Turner, and Turner[30] investigated the corrosion of fireclay pots or crucibles by molten glasses. The melted glass was then analyzed for the alumina and iron oxide increase over the calculated composition. This increase in alumina and iron oxide was taken as a result of the corrosion of the pot.

Hustin,[31] in analyzing brick before being installed in a forge reheating installation and after eight days of severe corrosion, found the SiO_2:Al_2O_3 ratio decreased considerably. After the first eight days, corrosion appeared to decrease. Hustin states, "It is reasonable to assume that after the solution of fusible silicates and free silica the exposed portion of the brick becomes richer in alumina which acts as a protective surface against rapid attack."

Dale[32] also found by chemical analysis that the silica-alumina ratio in a slag formed by interaction of iron scale with 70% silica fire brick in a billet reheating furnace is greater than the same ratio in the original brick itself. This again shows preferential solution of SiO_2 by iron oxide under reducing conditions with a consequent concentration of the more resistant alumina on the exposed surface.

VIII. A Record of the Progressive Alteration in the Temperature Gradient through a Wall, One Face of Which Is Exposed to the Solvent Action of a Corrosive Melt

An investigation of corrosion effects under actual working conditions was made by the Glass Research Association.[33] Thermocouples were mounted to the walls of a glass tank at different depths and locations, a continuous record of variation in the temperature gradient through the walls during several months' service. As a result, it was possible to draw up contour diagrams, illustrating clearly the velocity of wall-corrosion and erosion in different parts of this special type of furnace.

Sherman[34] used a similar method in studying the temperature gradient

[30] E. M. Firth, F. W. Hodkin, D. Turner, and W. E. S. Turner, *Jour. Soc. Glass Tech.*, **7**, 218 (1923); *Ceram. Abs.*, **3** [3], 68 and 69 (1924).

[31] R. Hustin, *Chim. & Ind.*, **14** [5], 691 (1925); *Ceram. Abs.*, **5** [12], 405 (1926).

[32] See footnote No. 28.

[33] Glass Research Association, *Bull.*, "Investigation into Erosion of Tank Blocks," 1925. See *Trans. Ceram. Soc.* [Eng.], **25**, 336 (1925–26).

[34] R. A. Sherman, "A Study of Refractory Service Conditions in Boiler Furnaces," U. S. Bur. Mines, *Bull.*, No. 334 (1931); *Ceram. Abs.*, **10** [6] 438 (1931).

produced in boiler refractories, but tests were conducted only over a few days' duration and were not conducted to final failure of refractory.

Data of this type are of extreme industrial value in suggesting change of furnace design, temperature control, the use of special refractories, of cooling devices, and of different types of fuel.

IX. Microscopic Examination of the Interface of Refractory and Slag after a Definite Heat Treatment

With constant improvement and broadening of microscopic technique the microscope has found ready application in the study of the corrosion and erosion of refractories.

Insley[35] studied the corrosion of refractories in glassmelting furnaces by means of thin sections of the interface of refractory and glass from industrial installations. Clay refractories below the glass line show a narrow white intermediate zone of mullite crystals between refractory and glass. The mullite crystals are embedded in a glassy matrix. Adjacent to the contact zone, but within the soda-lime glass, there is frequently found a small layer of hexagonal plates of corundum (Al_2O_3), from which Insley deduces the relative insolubility of corundum in the soda-lime glasses. The glassy matrix of the refractory is apparently attacked first, giving a highly viscous glass from which corundum is precipitated after a certain alumina content is attained. Corundum is therefore believed to be less soluble in these basic fluxes than the aluminum silicate. Therefore, alumina refractories should offer greater resistance to attack.

McDowell and Lee[36] made petrographic examinations of used and slagged boiler refractories and found that the principal phases present in the cooled slag were (1) plagioclase feldspar, (2) magnetite or hematite, (3) mullite with iron oxide in solid solution, and (4) glass. The interface between refractory and slag consists principally of mullite which, surrounded by the slag, has grown from fine needles to larger ones in the refractory. In high-alumina refractories where diaspore is present the stained interface is much thicker and grains of corundum are formed. Mullite is prominent on the outer surface but becomes mixed with corundum plates as the refractory is approached.

McVay and Hursh[37] examined petrographically samples of refractories subjected to the rotary furnace[38] test. Fireclay brick resist slag penetration because of the formation of a dense nonporous layer back of the slag contact caused by vitrification of the refractory. If there is a large amount of glass present, the grog particles are more easily eroded and removed.

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[35] H. Insley, *Jour. Amer. Ceram. Soc.*, **7** [8], 583 (1924).
[36] S. J. McDowell and H. C. Lee, *ibid.*, **11** [1], 35 (1928).
[37] T. N. McVay and R. K. Hursh, *ibid.*, **11** [11], 868 (1928).
[38] See footnote No. 22.

Diaspore brick are much more deeply penetrated by the slag, since on account of their high temperature of fusion they are still quite porous at furnace temperatures. After the pores are filled with the slag, further penetration is retarded.

Klinefelter and Rexford[39] have developed a method wherein slag contained in refractory crucibles is quenched after receiving a definite heat treatment. By studying petrographic thin sections prepared from these quenched samples of slag and refractory, the authors concluded that

> to obtain a relatively low corrosive slag, conditions should be such that the slag solution is well saturated at all times with solid phases formed from constituents of the slag only. This involves the determination of three temperature ranges: (1) the lower temperature range where slag is saturated with solid phase originating from its own components; (2) a critical temperature range, where most of the crystalline phases from the slag components have come into solution and the slag is mostly liquid; and (3) the upper temperature range, where the temperature is high enough to permit the brick components to unite with those of the slag to cause supersaturation and recrystallization of a solid phase.

The temperature should be kept below the critical range, as immediately above it severe corrosion of the refractory can be expected.

It is obvious from the above review that a wide variety of factors are contributory in the slagging of refractories. All or a part are instrumental in effecting failure and some are more important than others under certain conditions.

None of the laboratory slag tests so far developed appears to be able to take into consideration all the factors involved and properly weigh them. If large units are used, careful and accurate control is hard to maintain, considerable time is consumed, large amounts of material are used, and considerable expense involved. If small units are used, the composition of the slag may change during the test with diminished chemical activity and, furthermore, no account is taken of erosion.

In the evolution of satisfactory laboratory tests, penetration was looked upon at first as being of maximum importance. The need of differentiation between penetration and solution or chemical attack was soon noted. The cone fusion method was the next step, but this method obviously ignored penetration and erosion effects. The trend of developments has all very definitely been toward a better definition of the chemical relations involved between slag and refractory. A test which would show chemical attack as well as penetration would obviously have the greatest value. A study of thin sections of slag and refractory with the polarizing microscope offers considerable promise in tracing the progress of attack of refractory by the slag. Progress in this technique will be watched with interest in the near future.

BATTELLE MEMORIAL INSTITUTE
COLUMBUS, OHIO

[39] T. A. Klinefelter and E. P. Rexford, *Trans. A.S.M.E., Fuels & Steam Power*, **53** [22], 301 (1931); *Ceram. Abs.*, **11** [1], 38 (1932).

A STUDY OF HEATING AND COOLING RATES OF CHECKER BRICK*

By Gilbert Solbe and R. M. King

ABSTRACT

A test simulating the heat absorption and emission of checker brick was developed. The results of such tests on fire brick of two sizes, made by three different processes and procured from four fireclay districts, are given and correlated with the bulk specific gravity and porosity of the brick.

I. Introduction

The object of this investigation was to determine the possible relation between certain physical properties of a checker brick and its ability to absorb and emit heat. A comparison was made of samples of different sizes, made by various processes, from four of the main (geographical) centers of fireclay mining.

II. The Test

The test was designed to simulate regenerator conditions by alternately heating and cooling the test brick for a thirty-minute period between the extremes of 1800°F and 1400°F, and recording the temperature changes at the center and at the outside of the brick.

(1) Materials Tested The fireclay brick tested represented first-grade refractories from Ohio, Pennsylvania, Missouri, and Kentucky.

The brick used were soft mud (hand made), stiff mud (steam press), and dry press (power press). They were in two sizes, (1) $10^1/_2$ by $4^1/_2$ by $4^1/_2$ inches (checker brick), and (2), 9 by $4^1/_2$ by $2^1/_2$ inches (standard 9-inch brick).

All samples were obtained from one manufacturer who operates plants in the four districts represented, so as to standardize conditions as much as possible. All samples were fired to cones 11 to 13.

For purposes of comparison there were also tested one $10^1/_2$- by $4^1/_2$- by 3-inch fireclay brick and one 9- by $4^1/_2$- by $2^1/_2$-inch insulator brick.

(2) Apparatus Figure 1 illustrates the equipment used for the test.

(3) Physical Properties The following physical tests obtained for each brick were (*a*) porosity, (*b*) bulk specific gravity, (*c*) apparent specific gravity, and (*d*) true specific gravity.

Porosity was obtained by the gas-expansion porosimeter.[1] The values for specific gravity were obtained by the standard test methods.

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* Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (Refractories Division). Revised copy received March 17, 1931.

[1] E. E. Pressler, "A Simple Brick Porosimeter," *Jour. Amer. Ceram. Soc.*, **7** [2], 154–59 (1924).

III. Interpretation of Curves and Data

A typical time-temperature curve illustrating the rate of heating and

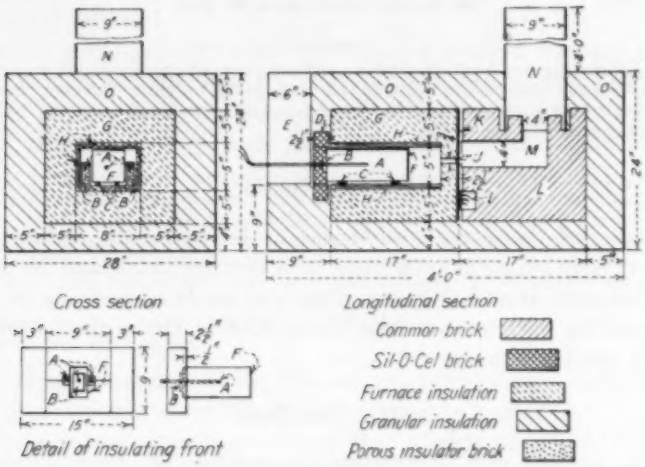

FIG. 1.—*A*, thermocouple; *B*, baffle; *C*, refractory support; *D*, insulating front; *E*, sheet-iron casing (bent); *F*, test brick; *G*, electric furnace; *H*, heating elements; *I*, duct for lead wires; *J*, cooling hole; *K*, backboard; *L*, stack setting; *M*, duct to stack; *N*, sheet-iron stack; *O*, granular insulation.

cooling of a checker brick is shown in Fig. 2. The heating-up curve of the outside of the brick is nearly parabolic, flattening out as it approaches the higher temperature. The cooling curve is the inverse of the heating-up curve, flattening out as it approaches the lower temperature. These curves, however, are determined by the conditions of the experiment.

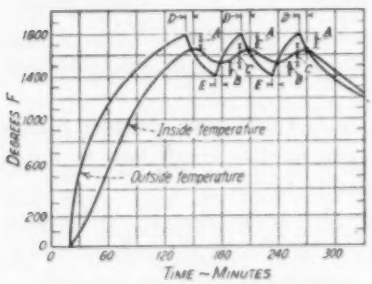

FIG. 2.—Typical time-temperature curve. *A*, difference between maximum inside temperature and maximum outside temperature; *B*, difference between minimum inside temperature and minimum outside temperature; *C*, difference between maximum and minimum inside temperature; *D*, time lag of maximum inside temperature behind maximum outside temperature; *E*, time lag of minimum inside temperature behind minimum outside temperature.

The rate of the temperature change of the inside of the brick follows the path of a sine curve, in which the cooling curve is symmetrical with the heating-up curve. This curve is more rounded for the larger sized brick and is also influenced by the conditions of the experiment.

When the furnace is reversed after heating up, the inside of the brick continues to rise in temperature, indicating that heat at some intermediate point in the brick is being

transmitted to the center and to the outside of the brick at the same time. A similar condition exists when the furnace is reversed after a cooling period. Heat from the center and from the outside of the brick is being transmitted to an intermediate point between the center and outside of the brick.

The slope of the inside temperature curve represents the rate of rise of temperature of the inside of the brick. This is an indication of the rate of heat absorption or heat diffusivity in brick of the same material, size, general composition, specific heat, specific gravity, and heat conductivity. If the slope is steep, the rate of heat absorption is high; if the slope is flatter, then the rate of heat absorption is low. As the time-interval is held constant at a one-half hour period, the difference between maximum and minimum inside temperature is a measure of the rate of heating of the brick. This value will be called the temperature differential.

TABLE I

Field and Process	Size (inches)	Temp. diff. (°F)	Lag period (minutes)	Porosity (%)	Bulk sp. gr. (g./cc.)	App. sp. gr. (g./cc.)	True sp. gr. (g./cc.)
Ohio hand made	9 x 4½ x 2½	150	8	25.16	1.94	2.59	2.72
" steam press	"	150	8	15.96	2.14	2.55	2.75
" power press	"	150	8	18.48	2.11	2.59	2.74
Pa. hand made	"	125	8	20.63	2.08	2.62	2.73
" steam press	"	125	8	16.67	2.16	2.59	2.71
" power press	"	125	8	17.69	2.09	2.53	2.72
Mo. hand made	"	175	8	25.79	1.97	2.66	2.73
" steam press	"	175	8	17.33	2.20	2.66	2.73
" power press	"	175	8	20.76	2.08	2.62	2.71
Ky. hand made	"	150	9	27.68	1.93	2.66	2.71
" steam press	"	150	9	20.70	2.13	2.68	2.70
" power press	"	150	9	19.49	2.12	2.63	2.70
Porous insulator	"	175	6	73.34	0.57	2.13	
Fire clay	10½ x 4½ x 3	125	10	27.06	1.92	2.63	
Ohio hand made	10½ x 4½ x 4½	75	18	22.34	1.99	2.56	2.72
" steam press	"	75	18	15.76	2.11	2.51	2.75
" power press	"	75	18	22.05	2.05	2.63	2.74
Pa. hand made	"	75	19	16.00	2.10	2.50	2.73
" steam press	"	75	19	19.88	2.02	2.52	2.71
" power press	"	75	19	17.01	2.02	2.44	2.72
Mo. hand made	"	100	18	22.34	2.02	2.60	2.73
" steam press	"	100	18	15.20	2.18	2.57	2.73
" power press	"	100	18	23.68	1.95	2.55	2.71
Ky. hand made	"	75	19	22.11	2.05	2.55	2.71
" steam press	"	75	18	18.89	2.13	2.62	2.70
" power press	"	75	18	19.00	2.06	2.55	2.70

Table I gives the temperature differential values and the physical properties of the brick tested. It is to be noted that there is an apparent physical similarity between the brick tested in regard to apparent and true specific gravity. Bulk specific gravity in general varies as the porosity.

There is no marked relation between the heat differential values of the

brick of one size and their porosity or bulk specific gravity. There is, however, a marked variation of heat differential values as to source of brick; brick from Missouri have the highest values, Ohio and Kentucky next, and Pennsylvania the lesser values. Evidently the physical properties of a brick which are dependent upon the original source of the clay are more important than such properties as porosity which are imparted by process of manufacture.

The lag of the inside temperature behind the outside temperature is the same on reversing the furnace, whether heating up or cooling down. This indicates that the rate of absorption at the surface and transfer of heat to the center of the brick is equal to the rate of transfer from the center and emission of heat from the surface of the brick.

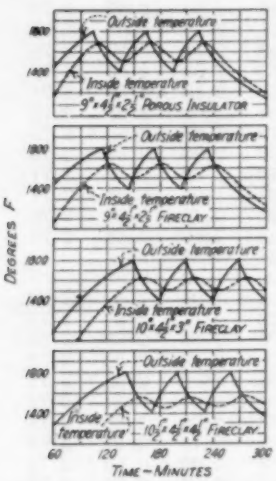

FIG. 3.—Time-temperature curves for various brick.

From a study of the curves for the $10^1/_2$- by $4^1/_2$- by $4^1/_2$-inch, $10^1/_2$- by $4^1/_2$- by 3-inch, and 9- by $4^1/_2$- by $2^1/_2$-inch brick shown in Fig. 3, it is evident that the lag of the $10^1/_2$- by $4^1/_2$- by $4^1/_2$-inch brick is greater than that of the smaller sizes. The inside temperature curve is also more rounded. This indicates that the longer the lag time the greater the period of counterflow of heat to and from intermediate points, and consequently the thinner brick should be able to absorb and emit heat more readily than the thicker brick. The relative average values from Table I as measured by lag period are 18:10:8 for $4^1/_2$- by 3- by $2^1/_2$-inch thickness, respectively.

The inside temperature curve of the porous insulator brick, shown in Fig. 3, indicates that it heats up more rapidly than the denser fireclay brick. The lag time is consequently shorter.

There has been a difference of opinion as to whether a highly porous brick with a large heat contact surface due to the channel pores would absorb and emit a greater quantity of heat than a very dense brick of the same material with a relatively small contact surface.

In a very porous brick the rate of temperature rise is greater than in a dense brick, but the total heat absorbed will be greater in a dense brick than in a porous one, due to its weight. Therefore, the total heat absorbed in a given time would be a function of the bulk specific heat (heat capacity per unit volume) and rate of temperature rise of the inside of the brick.

The point at which the amount of heat absorbed is the greatest might be a very dense brick, it might be an intermediate point, or it might be

a very porous brick. Further work would be required to establish this optimum point.

If one compares an extremely porous checker brick with many channel pores to a dense brick, as one would compare a regenerator with its flue system to a regenerator made of one huge solid fireclay block, then it is conceivable that a very porous checker brick might be more efficient than a very dense checker brick. In practice, however, such a porous brick would soon become glazed over or the pores clogged with flue dust.

IV. Conclusions

The data indicate that there is no marked difference in the rate of absorption and emission of heat by fireclay checker brick due to a difference in porosity of the brick as manufactured by the usual processes.

From a study of the rate of rise of temperature within the three sizes of checker brick, it is concluded that heat would be more readily absorbed by or transmitted from the smaller checker brick due to the difference in thickness.

The rates of absorption of heat and the transfer of that heat to the center of a brick are equal to the rates of transfer and emission of the heat from the body.

The rates of heat absorption and emission for the fireclay brick tested in this experiment have little variation due to process of manufacture, but they do vary in the following order as to source: greatest, Missouri, second, Ohio and Kentucky, third, Pennsylvania.

NOTE: This paper is a contribution from the Ohio State University Engineering Experiment Station checker brick investigation.

LORD HALL, O. S. U.
COLUMBUS, OHIO

A MODULUS OF RUPTURE CHART FOR CYLINDRICAL TEST PIECES*

By R. G. Mills

ABSTRACT

A three-variable alignment chart is presented which has been found useful for the solution of the modulus of rupture equation for cylindrical test pieces. The chart is easily prepared and its use eliminates routine calculations. Factors affecting the accuracy are mentioned.

I. Introduction

A type of chart similar to that described in this paper has been previously presented.[1] That chart differs in form from the present one as it was prepared for use with rectangular test pieces. Since cylindrical test specimens also are used for modulus of rupture determinations, the present form has been prepared.

II. Equations and Chart

The modulus of rupture equation for cylindrical test pieces is as follows:[2]

$$MR = \frac{8PL}{\pi d^3}$$

Where MR = modulus of rupture (lb./sq. in.)
P = load at rupture (lb.)
L = distance between supports (in.)
d = diameter of specimen (in.)

If the value of L is fixed this equation may be expressed in three variables. The value of L generally used is 5 inches. The equation becomes

$$MR = \frac{5 \times 8}{\pi} \cdot \frac{P}{d^3} \text{ or } MR = 12.73 \frac{P}{d^3}$$

Reference to a standard text on graphical computation[3] revealed a form of nomographic or alignment chart, known as the Z chart. This form may be used for charting equations of the general type

$$f_1(v) = \frac{f_2(u)}{f_3(w)}$$

To chart the equation three axes were drawn, two of which were parallel and oppositely directed and the third, a diagonal which cut the first two (see Fig. 1). With the intersections of the diagonal as origins, the P and MR scales were laid off. The maximum value of P, the load, was set at 2000 pounds, and the maximum value of MR, modulus of rupture, was set at 20,000 pounds per square inch. Each axis was 10 inches long;

* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (White Wares Division). Received March 2, 1932.

[1] R. G. Mills, "Solution of the Modulus of Rupture Equation by Means of a Simple Four-Variable Chart," *Jour. Amer. Ceram. Soc.*, **14** [10], 729–32 (1931).

[2] Standards Report, "Methods of Testing Electrical Porcelain," *ibid.*, **11** [6], 472 (1928).

[3] Joseph Lipka, Graphical and Mechanical Computation, John Wiley & Sons.

therefore the scale for the P axis equals 200 pounds per inch and that for the MR axis equals 2000 pounds per square inch per inch.

The d scale was then laid off on the diagonal axis. Limiting values of 0.5 inch and 1.50 inches were chosen. The scale was graduated in 0.01-inch divisions, thus requiring 100 divisions. The d values were obtained by substituting assumed values for P and d in the original formula and obtaining a value for MR. A straight line was then drawn on the chart from the MR value to the assumed P value. The intersection of this line with the diagonal axis was plotted as the assumed value of d. This calculation was made for each of the 100 values of d.

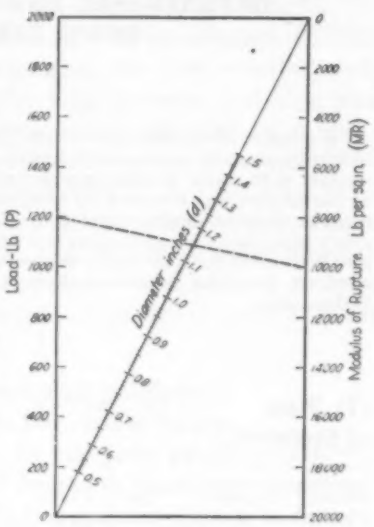

FIG. 1.

Other methods exist for plotting the values of a variable on the diagonal scale which may be employed when circumstances will not permit the use of that described.

III. Use

The chart is direct-reading and is of the simplest form in that it requires no construction lines in order to use it. A straight edge is placed on the given load value, P, and on the value for the given diameter, d. The value for the modulus of rupture is then read directly from the intersection of the straight edge with the MR axis.

Example: Given $P = 1200$ lb.
$d = 1.15$ inches
Determine modulus of rupture

The broken line in Fig. 1 represents a straight-edge joining the P value of 1200 to the d value of 1.15 and its intersection with the MR axis shows the MR value to be about 10,050, which is the calculated value.

IV. Accuracy

The accuracy of the chart is dependent upon its size, the limits of the variables, and the care used in its construction. Figure 1 is sufficiently accurate so that modulus of rupture values may be read which are within 200 pounds of the calculated value. Ordinary testing requirements do not necessitate the use of such a wide range of variables and a chart prepared for such use would have a correspondingly greater accuracy.

DEPARTMENT OF CERAMICS
RUTGERS UNIVERSITY
NEW BRUNSWICK, N. J.

THE EFFECT OF MECHANICAL PRESSURE ON THE IMBIBITIONAL AND DRYING PROPERTIES OF SOME CERAMIC CLAYS, I*

By A. E. R. Westman

ABSTRACT

A number of ceramic clays in the plastic condition were held between water-permeable pistons under mechanical pressure of from 200 to 20,000 pounds per square inch in contact with water at atmospheric pressure until equilibrium was reached; the water in the pistons was removed by compressed air, the pressure released, and the moisture content, density, drying shrinkage, and other properties of the clays determined. In every case, the moisture content and drying shrinkage decreased with increasing pressure and with some clays at high pressures expansion occurred on drying. Rather complete data are given for a number of clays and their theoretical and practical significance is discussed.

I. Introduction

(1) Field of Study In studying the forces which may act between clay and water, or clay, water, and air, a general method is to oppose the force under study by an external, controlled force. Thus, in experiments previously described by the writer,[1] the capillary suction of a system of water, wet clay, and air was opposed by the pressure of the air. The experiments described in the present paper belong to a similar field of study in which forces acting between clay and water are opposed by mechanical pressure applied to the clay only, the water being free to move.

Experiments in this field have been described by Mellor,[2] Terzaghi,[3] and Cunningham.[4] Mellor found that the water required by an earthenware body for maximum stickiness was 26.4% at atmospheric pressure and only 5.6% at 2850 lb. per sq. in. Terzaghi applied mechanical pressure to a yellow, residual clay and a blue marine clay by means of a water-permeable sand-filter which remained in contact with the clays as the pressure was released. With clay layers one centimeter thick and pressures up to 285 lb. per sq. in., he found that at least 24 hours were required for equilibrium, that approximately one-third the water of plasticity could be removed, and that cyclic loading showed hysteresis effects. He pointed out the analogy between mechanical pressing and air-drying and estimated that capillary forces during air-drying exerted pressures of 2400 and 4800 lb. per sq. in. for the residual and marine clays, respectively. Cunningham, working primarily with clay slips, centrifuged clay pastes, decanted the supernatant water after the centrifugal force had been removed, and

* Presented at the Annual Meeting, American Ceramic Society, Washington, D. C., February, 1932 (White Wares Division). Received June 20, 1932.

[1] A. E. R. Westman, "The Capillary Suction of Some Ceramic Materials," *Jour. Amer. Ceram. Soc.*, **12** [9], 585–95 (1929).

[2] *Trans. Ceram. Soc.* [Eng.], **21**, 91 (1921–22); *ibid.*, **29**, 177 (1930).

[3] C. Terzaghi, "Principles of Soil Mechanics," *Eng. News-Rec.*, McGraw-Hill Publishing Co. (1926).

[4] G. E. Cunningham, "The Mechanism of Plastic Flow," *Jour. Phys. Chem.*, **35** [3], 796–814 (1931).

determined the moisture content of the residues. His highest speed corresponded to a pressure of about one-tenth that used by Terzaghi.

(2) Purpose and Scope The experiments to be described were undertaken with the two-fold purpose of determining the properties of well-known ceramic clays under high pressure and obtaining information regarding the feasibility of molding ceramic ware by subjecting clay to pressure in contact with water which was free to move. With this in mind, the imbibitional and drying properties of the eight clays listed in Table I were determined at atmospheric pressure and at pressures of approximately 200 and 8000 lb. per sq. in., and the rate of water removal, effect of still higher pressures, etc., were studied. The rational analyses given in the table were calculated from chemical analyses supplied by the

TABLE I

DATA OBTAINED FROM CLAY COMPANIES

Name of clay	Brand	Mine location	Approximate Rational Analysis	
			Clay substance	Non-plastic
Jernigan black ball	Jernigan	Paris, Tenn.	80	20
Dorsetshire English ball	Enfield crude lump	Dorsetshire, England	70	30
Vallendar	Vallendar	Vallendar-on-Rhine, Germany	80	20
Florida kaolin	Edgar washed plastic	Edgar, Fla.	92	8
Delaware kaolin	No. 2 Golding china clay	Hockessin, Del.	91	9
Georgia kaolin	No. 1 Klondike washed lump	McIntyre, Ga.	91	9
Kentucky fire clay	No. 6 plastic	Mayfield, Ky.	60	40
Grossalmerode	Grossalmerode	Grossalmerode, Germany	50	50

clay companies, clay substance being considered the only plastic material present.

(3) Technique Required In order to obtain reliable data on the imbibitional and drying properties of the clays at high pressures, it was necessary to develop an apparatus and procedure such that clay initially in the plastic state could be subjected to a known, steady, mechanical pressure in contact with water that was free to move, slaking of the clay and trapping of air being avoided. Pressure gradients in the clay should be small, equilibrium reached quickly, and means for recognizing it be provided. It was essential that all excess water be removed before releasing the pressure and that accurate moisture, volume, and drying shrinkage determinations be possible. Satisfactory removal of excess water could not be accomplished readily by the procedure of Terzaghi or Cunningham but was deemed essential in high-pressure work since immediate elastic expansion of the clay was to be expected when the

pressure was released. These somewhat conflicting requirements were met satisfactorily by the apparatus and procedure to be described.

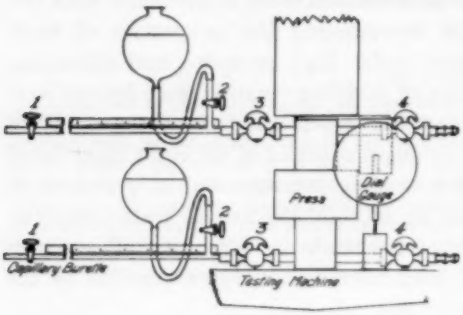

FIG. 1.—General assembly of apparatus.

(4) Apparatus As shown in Fig. 1, the apparatus included a press which could be assembled in a testing machine, a dial gage, and two capillary burettes provided with reservoirs. Figure 2 shows the detailed construction of the press, which consisted essentially of a ring and two permeable pistons of medium steel. The ring was designed for an internal hydraulic pressure of 22,000 lb. per sq. in. with a factor of safety of one, and suffered no damage when used to press clay at 20,000 lb. per sq. in.

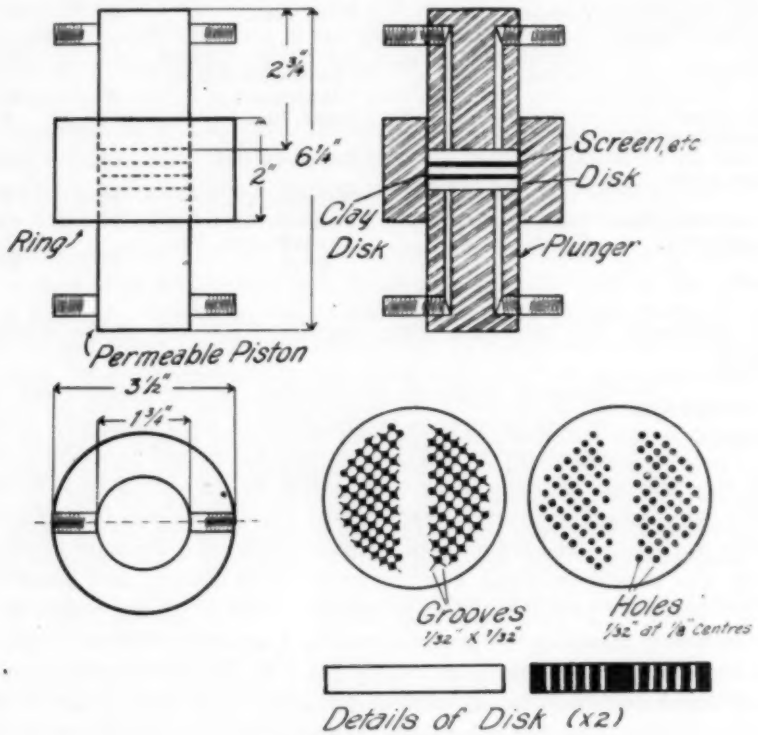

FIG. 2.—Details of press.

Each permeable piston consisted of a steel plunger, a steel disk, a bronze screen, a filter-paper support, and a filter paper. The plunger was $1^3/_4$ inches in diameter and had two closed-end longitudinal perforations connected laterally to $^1/_8$-inch pipe nipples. The steel disk had two groups of 45 holes, $^1/_{32}$ inch in diameter at $^1/_8$-inch centers, separated by an unperforated strip $^1/_4$ inch wide along a diameter. On one face of the disk, the holes in each group were interconnected by grooves $^1/_{32}$ inch wide and deep; the screen, which was cut from 40-mesh gauze, was wired to the other face. The grooved side of the disk was placed against the plunger so that each group of holes communicated with one, and only one, perforation in the plunger. The No. 123 C.S. & S. filter-paper support was in contact with the screen and carried a No. 50 Whatman hard filter paper. With most clays the filter-paper support was unnecessary. For proper functioning of the apparatus, a good fit between pistons and ring was necessary but friction was to be avoided. These somewhat conflicting requirements were met by nickel-plating the plungers and disks until they were oversize, rubbing them down to a snug fit, applying a thin chromium plate to reduce wear, and coating their curved surface with vaseline.

The testing machine was a 50,000-pound hydraulic machine with an automatic load maintainer and a load indicator of the self-balancing type correct to less than 1%. The dial gage was graduated in ten-thousandths of an inch and had a spindle travel of $^2/_5$ inch. It was clamped to a flat brass bar fastened to the upper surface of the top permeable piston and recorded movements of the pistons relative to each other. Each capillary burette consisted of a 2.5-mm. inside diameter glass capillary clamped to a meter stick and provided with a side tube and two glass stopcocks labeled 1 and 2 in Fig. 1. They were calibrated gravimetrically with mercury. Heavy rubber tubing connected them to the permeable pistons, brass stopcocks (3, Fig. 1) being interposed. Similar stopcocks (4, Fig. 1) were provided at the other outlets of the permeable pistons to which compressed air could be applied.

(5) General Procedure The clays were blunged for at least eight hours, allowed to dry to the plastic state on cloth-covered plaster bats, wedged thoroughly, and stored in damp jars. Disks $1^3/_4$ inches in diameter and $^1/_4$ inch thick were molded as required in a plaster mold just prior to insertion in the apparatus.

The apparatus was assembled as shown in Figs. 1 and 2 with a clay disk between the permeable pistons, stopcocks 1, 3, and 4 open, stopcocks 2 closed, and water in the reservoir only. Sufficient pressure was applied to bring the clay into good contact with the pistons and ring, the air escaping through 3 and 4. By closing 1 and opening 2 and 3, the air in the permeable piston and in contact with the clay escaped through 4 and was replaced by water from the reservoir. With 4 closed, the menisci in the capillary

burettes were adjusted to convenient starting points and the experiment commenced with 1 and 3 open and 2 and 4 closed.

The pressure exerted by the machine was increased to 500 lb. or 207 lb. per sq. in., and readings of the dial gage and capillary burettes were made at two-minute intervals until the dial gage readings were constant for 8 minutes. The pressure was then raised within a minute to the final value (if different from 500 lb.) and readings were taken as before. The capillary burettes were disconnected, stopcocks 4 opened, and air at about 40 lb. per sq. in. pressure used to blow the water in the permeable pistons and in contact with the clay out through 3. Then the pressure exerted by the machine was released, the ring was pushed down on the lower piston by pressure applied through wooden blocks placed on either side, the upper permeable piston was removed, and the clay disk placed in a tared weighing bottle provided with a ground-in glass lid.

For each clay, four such disks were made, two at final pressures of 207 lb. per sq. in. and two at 8280 lb. per sq. in. The moisture content of one of

TABLE II

SPECIAL EXPERIMENTS WITH DELAWARE KAOLIN

Procedure	Moisture Content of Disks (grams water/100 grams dry clay)	
	207 lb./sq. in.	8278 lb./sq. in.
(1) Usual (par. 5)	26.6	10.4
(2) With water-saturated compressed air	26.8	9.7
(3) Pressure released before purging apparatus	31.1	19.5

each pair of disks was determined by drying at 110°C for 5 hours in accordance with AMERICAN CERAMIC SOCIETY standards, handling of the disks and extraneous moisture changes being avoided by the use of weighing bottles. The plastic and dry volumes of the other disks were determined by methods based on the AMERICAN CERAMIC SOCIETY standards but refined so as to give accurate results with small disks by using weighing bottles, pycnometers, etc. At the same time their moisture contents were determined as a check on the first disks but were not necessarily as accurate since the disks were handled in making volume measurements.

(6) Special Experiments Disks of Delaware kaolin were made at 207 and 8280 lb. per sq. in. (1) by the general procedure described in the previous paragraph, (2) by using water-saturated compressed air, and (3) by purging with compressed air immediately after rather than before releasing the pressure. The moisture contents of the disks, so prepared, are given in Table II and show that no appreciable drying of the clay was caused by purging with compressed air in the usual manner, and that large errors were introduced when the pressure was released before purging, particularly at the high pressure.

(7) Reproducibility of Data In connection with a number of special experiments, disks of Delaware kaolin were made by the usual procedure at 207 lb. per sq. in. and 8280 lb. per sq. in. on several occasions during a period of six months. On each occasion two disks were made at each pressure; one was used for determining moisture content and the other for both moisture and shrinkage determinations. The duplicate moisture contents so obtained and the dates of the experiments are given in Table III and show that quite reproducible

TABLE III

REPRODUCIBILITY OF DATA

	Moisture Content of Disks of Delaware Kaolin (grams water/100 grams dry clay)			
	Made at 207 lb./sq. in.		Made at 8280 lb./sq. in.	
Date (1931)	For moisture	For moisture and shrinkage	For moisture	For moisture and shrinkage
May 29	25.93	26.17	9.42	9.59
October 5	26.65	26.80	10.38	9.67
October 15	26.04	26.84		
October 30	27.03	26.23		
November 3	26.45	26.22		
Average	26.42	26.45		

results could be obtained by careful work, particularly at the low pressure, and that disks used for both moisture and shrinkage determinations give accurate moisture values.

II. Equilibrium Data

(8) Atmospheric Pressure The true specific volumes of the clays and their drying properties when made into hand-molded briquets are given in Table IV. The specific volumes were determined in kerosene by the American Society of Testing Materials Method D 153–27 using a water bath at 25°C, and the drying properties by a refinement of the AMERICAN CERAMIC SOCIETY Standard Method.[5] In the table all weights are reported in grams per 100 grams of dry clay and all volumes in cubic centimeters per 100 cubic centimeters of dry clay. This permits ready visualization of the changes occurring on drying. The test values usually reported can be readily found from those in the table; thus column (2) gives the water of plasticity and 100 times column (7) divided by column (6) gives the volume drying shrinkage in standard units. Column (5) was obtained by subtracting 100 + (4) from (3) and gives the difference between the volume of the plastic briquet and the sum of the volumes of the clay and water of which it was composed. This difference in volume is called "air volume" for convenience. It might be caused by swelling of the clay or by errors in measurement.

[5] *Jour. Amer. Ceram. Soc.*, **11** [6], 449–51 (1928).

Column (7) of Table IV shows that all of the clay briquets suffered a marked decrease in volume on drying. This was largest for the clays of the ball clay type and least for the china clay type. The air volumes of the

TABLE IV

PROPERTIES OF BRIQUETS HAND-MOLDED AT ATMOSPHERIC PRESSURE

(Weights in grams/100 grams dry clay, vol. in cu. cm./100 cu. cm. dry clay)

Clay	Dry clay (true specific volume)*	Plastic briquet				Dry briquet (total volume)	Drying change (total volume)
		Weight of water	Total volume	Water volume	Air volume		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Jernigan black ball	38.42	45.0	218.0	117.6	0.4	162.4	−55.6
Dorsetshire English ball	37.62	37.3	198.0	99.5	−1.5	144.6	−53.4
Vallendar	37.07	40.1	211.2	108.5	+2.7	160.3	−50.9
Florida kaolin	38.50	41.3	210.4	107.7	+2.7	163.4	−47.0
Delaware kaolin	38.24	35.4	193.8	92.9	+0.9	164.2	−29.6
Georgia kaolin	38.59	35.9	193.3	93.3	0.0	168.5	−24.8
Kentucky fire clay	37.97	26.0	169.3	68.8	+0.5	136.6	−32.7
Grossalmerode	37.78	23.3	162.9	61.9	+1.0	127.0	−35.9

* In absolute cc./g. at 25°C against brass weights in air, multiplied by 100.

plastic briquets, column (5), were negligible except possibly for Vallendar clay and Florida kaolin.

(9) Low Pressure Table V gives the properties of disks made from the clays by the general procedure of paragraph 5 with 207 lb. per sq. in. as the final gross pressure. Column (1) gives the mois-

TABLE V

PROPERTIES OF CLAY DISKS MADE AT 207 LB./SQ. IN. GROSS PRESSURE

(Weights in grams/100 grams dry clay, vol. in cu. cm./100 cu. cm. dry clay)

Clay	Wet Disk					Dry Disk (total volume)	Drying change (total volume)
	Weight of water		Total volume	Water volume	Air volume		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Jernigan black ball	30.6	30.1	178.0	78.6	−0.6	163.5	−14.5
Dorsetshire English ball	28.4	27.5	171.6	73.3	−1.7	146.7	−24.9
Vallendar	32.4	31.1	183.6	84.1	−0.5	161.6	−22.0
Florida kaolin	32.5	32.5	184.1	84.7	−0.6	165.9	−18.2
Delaware kaolin	26.0	26.2	168.6	68.6	0.0	166.8	− 1.8
Georgia kaolin	28.7	28.6	173.5	74.3	−0.8	170.6	− 2.9
Kentucky fire clay	19.3	19.1	150.0	50.3	−0.3	136.3	−13.7
Grossalmerode	17.2	18.9	148.9	50.2	−1.3	130.5	−18.4

ture contents of the disks used for moisture determinations only and column (2) those of the disks used for both moisture and shrinkage determinations. The remaining columns are similar to those in Table IV.

It will be noted that the moisture contents (2), total wet volumes (3), water volumes (4), and drying changes (7), are much smaller than those in

Table IV, that the air volumes are still negligible, and that the total dry volumes (6) are practically the same. The very small volume drying change of the china clays is particularly striking.

(10) High Pressures Table VI gives the corresponding properties of disks of the eight clays made by the procedure of paragraph 5 with 8280 lb. per sq. in. final pressure, and in addition values for Delaware kaolin and an English china clay at twice this pressure.

A comparison of the values in Table VI with the corresponding values in Table V shows still lower moisture contents (2), wet volumes (3), and water volumes (4). The air volumes (5) are relatively large except for the fire clays and the total dry volumes (6) are much smaller. Total volume

TABLE VI

PROPERTIES OF CLAY DISKS MADE AT 8280 LB./SQ. IN. GROSS PRESSURE AND 16,560 LB./SQ. IN.

(Weights in grams/100 grams dry clay, vol. in cu. cm./100 cu. cm. dry clay)

Clay	Wet Disk					Dry Disk (total volume) (6)	Drying change (total volume) (7)
	Weight of water (1)	(2)	Total volume (3)	Water volume (4)	Air volume (5)		
			8280 lb./sq. in.				
Jernigan black ball	10.3	10.3	138.6	26.8	11.8	135.6	−3.0
Dorsetshire English ball	13.8	11.0	138.8	29.5	9.3	138.4	−0.4
Vallendar	14.2	13.1	150.8	35.5	15.3	148.4	−2.4
Florida kaolin	11.7	12.0	140.4	31.3	9.1	138.6	−1.8
Delaware kaolin	9.4	9.6	134.3	25.1	9.2	134.6	+0.3
Georgia kaolin	11.9	11.3	144.3	29.3	15.0	143.8	−0.5
Kentucky fire clay	8.0	7.4	120.9	19.6	1.3	126.8	+5.9
Grossalmerode	9.1	10.1	127.1	26.7	0.4	124.7	−2.4
			16,560 lb./sq. in.				
Delaware kaolin		6.6	126.6	17.4	9.2	126.8	+0.2
English china clay		6.5	126.9	15.8	11.1	133.0	+6.1

changes on drying (7) have become very small or negligible, or show a reversal of sign indicating expansion on drying.

By increasing the pressure on the Delaware kaolin to 16,560 lb. per sq. in., a further decrease in moisture content (2), total wet volume (3), water volume (4), and total dry volume (6) took place, but the air volume and drying change remained the same. The English china clay showed a pronounced expansion on drying after being pressed at 16,560 lb. per sq. in.

Thus, for both the Kentucky fire clay and English china clay, quite significant expansions on drying were shown. That this was not due to errors of measurements was verified by the fact that the dry disks were much too large to go in the steel ring in which they had been made.

(11) Graphic Presentation The data in Tables IV, V, and VI showed that the eight clays fell into three groups which could be represented by Jernigan black ball clay, Delaware kaolin, and Kentucky

fire clay. The volume data for these three clays are plotted graphically in Fig. 3, so that the changes occurring on pressing or drying may be visualized readily.

The equality between the total dry volumes at atmospheric pressure and at 207 lb. per sq. in. is quite evident and shows that this pressure does not produce changes in volume which would not ordinarily occur on drying. For the Kentucky clay, the pressing anticipates somewhat more than one-half the drying change; for Jernigan about three-quarters, and for the china clay over 95%. At 8280 lb. per sq. in. the dry volumes of the three clays are much smaller than those ordinarily obtained on drying and the wet volumes are greater than the sum of the volumes of water and clay for the Jernigan and china clay. In each case the sum of the volumes of the clay and water indicates the total volume in the press before the pressure was relieved; the air volume is due to air sucked in on the release of pressure.

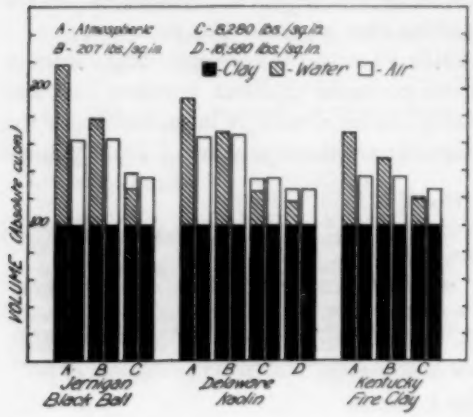

FIG. 3.—Volume data for typical clays at several pressures.

(12) Summary The data of Tables IV, V, and VI show that by pressing clay disks in the plastic state between permeable pistons as described in paragraph 5, the following results were obtained: (1) Their plastic volumes could be reduced to equality with their usual dry volumes by the application of relatively low pressures, somewhat more than 200 lb. per sq. in. for china clays, and roughly 800 lb. per sq. in. for more plastic clays; (2) this procedure eliminated nearly all shrinkage on drying; and (3) by using higher pressures the plastic volumes of the disks could be reduced to less than their usual dry volumes; the release of pressure was usually accompanied by an increase in volume and an intake of air, and drying showed little or no shrinkage or else a definite expansion.

III. Discussion

(13) Theoretical Significance The equilibrium data of the previous chapter were of theoretical interest in that the phenomena occurring in the usual treatment of clay could be examined in the light of those happening at several degrees of mechanical pressure. For example, the striking analogy between pressing between permeable

pistons at low pressure under conditions which made cracking impossible, and air drying under conditions which were apt to cause cracking, threw some doubt on the usual explanation of drying cracks. This phase of the subject will be discussed in detail in a later paper in which further experiments will be described. The present discussion will be limited to a consideration of particle packing and clay differentiation.

(14) Particle Packing If only those mechanical pressures at which drying shrinkage was negligible were considered, *e.g.*, greater than about 250 lb. per sq. in. for china clays and 800 lb. per sq. in. for ball clays, the data obtained could be readily explained by specifying a system of flexible, mechanically weak, solid particles in solid contact with each other. Since the capillary forces set up on drying, as reported in a previous paper, would be less than the mechanical forces already applied, no change in volume would occur on drying. The consolidation which occurred under high pressures would be due to crushing and flexing of the particles, the reversal or partial reversal of the latter accounting for the intake of air when the pressure was released. It appeared not only unnecessary but a disadvantage to consider that the particles were jelly-like or separated by an appreciable water film since either condition would anticipate a drying shrinkage which was not observed. The density of packing was not less than might be expected from such a system when the ease of crushing of the particles and their range of sizes were considered.[6]

At lower mechanical pressures it was necessary to account for drying shrinkage. This could be done, in part, by considering that the capillary forces which acted during drying were higher than the mechanical forces which had acted on the clay and, consequently, caused closer packing and crushing. Some modification of the assumed system of particles appeared necessary, however, since the high plastic volumes of such clays as Jernigan black ball would require a very loose packing which appeared inconsistent with their strength in the plastic state. The simplest modification was to consider that the particles were separated by water films whose thickness decreased with pressure and became negligible at high pressures.

(15) Differentiation of Clays As has been indicated by the grouping in Tables IV, V, and VI, the clays examined could be divided into three groups. The first group included Jernigan black ball clay, Dorsetshire English ball clay, Vallendar clay, and Florida kaolin, the second, Delaware kaolin and Georgia kaolin, and the third, Kentucky fire clay and Grossalmerode clay; for convenient reference they will be called ball clays, china clays, and fire clays, respectively.

The most striking differentiation between the groups was shown by the

[6] A. E. R. Westman and H. R. Hugill, "The Packing of Particles," *Jour. Amer. Ceram. Soc.*, **13** [10], 767–79 (1930).

change in volume on drying which is given in the last column of Tables IV, V, and VI. At atmospheric pressure, the china clays have a relatively small change in volume on drying, the fire clays a somewhat larger change, and the ball clays a large change; at 207 lb. per sq. in. the china clays have almost no volume change on drying, and the ball clays and fire clays, a small change; at 8280 lb. per sq. in. none of the clays has a marked shrinkage on drying. In general, the china clays and ball clays differed greatly in their drying shrinkage at atmospheric pressure and in the pressure required to prevent drying shrinkage. The fire clays acted as ball clays diluted with nonplastic material, as might have been expected from their analyses (see Table I).

The most striking difference between the ball clays and fire clays was shown by the packing ability of the fire clays. This was evident from the total dry volumes and the air volumes given in columns (5) and (6) of Tables IV, V, and VI. The fire clays evidently packed to a much greater extent at all pressures, although the difference tended to disappear at very high pressures, *e.g.*, Delaware kaolin at 16,560 lb. per sq. in., and, in addition, they tended to stay packed, drawing in very little air when the pressure was removed. These characteristics were probably due to the packing of the fine clay particles between the relatively coarse particles of nonplastic.

(16) Practical Significance The apparatus and technique described constitute a method of molding ceramic ware and although it is not the purpose of this paper to discuss its commercial value, it is interesting to compare it briefly with the usual plastic processes in which ware is molded in the plastic state and subsequently dried.

With pressures just sufficient to prevent drying shrinkage, the new process is equivalent to the usual process of molding and that part of the drying process during which shrinkage takes place and allows closer control of the dry size; with higher pressures, much denser dry ware than that given by the usual processes is produced and the firing properties, which will be described in a later paper, considerably modified. Many of the considerations which influence the choice of clays for the usual plastic processes, *e.g.*, tenderness, drying shrinkage, etc., have no weight with the new process, thus simplifying the compounding of bodies.

The most obvious disadvantage of the new process, *e.g.*, the time required for molding, was one that tended to disappear on closer examination. In molding the disks which have been described, the approach to equilibrium took place in two stages. The first stage, during which nearly all the water was removed, was completed almost as soon as the pressure reached its final value, the second stage required several minutes but resulted in only a small water loss. The saving in drying time should also be considered.

From a more general viewpoint the rate at which shrinkage water could be removed from ware in the usual process was limited by the necessity of avoiding cracks and, even if cracking were not a factor, it would be limited by the rate of evaporation from the surface and the rate at which water was brought to the surface by such forces as capillary suction. With the new process none of these limitations applied and forces much greater than capillary suction were available. The latter is an important consideration when dealing with thick-walled ware.

IV. Conclusions

The following results are obtained when clays in the plastic state are pressed in contact with water between permeable pistons and the expressed water is removed before the pressure is released:

(1) The effects of the shrinkage stage in air drying are obtained at relatively low pressures approximating those required to overcome the capillary suction of the clays.
(2) Higher pressures increase the rate of water removal and give higher dry densities than air drying.
(3) Ball clays and china clays appear to be sharply differentiated at low pressures but not at high pressures.
(4) At high pressures many of the usual differences between clays disappear, *e.g.*, drying shrinkage, tendency to crack, etc.
(5) The water of plasticity can be removed more quickly than by air drying, and drying shrinkage, drying cracks, and variation in dry size are largely eliminated.

Acknowledgments The writer wishes to express his gratitude to H. B. Speakman, Director of the Ontario Research Foundation, for the facilities and help which made the investigation possible, and to F. Rutland, Laboratory Assistant, whose careful work is shown by the consistency of the data in the tables.

Ontario Research Foundation
47 Queen's Park
Toronto 5, Canada

PETROGRAPHIC AND MINERALOGICAL STUDY OF THE UNDERCLAYS OF ILLINOIS COAL*

By Victor T. Allen

ABSTRACT

A study was made of the petrographical and mineralogical characteristics of Illinois underclays, which were found to be mainly potash beidellite purified before deposition under the conditions of the Pennsylvanian period. Feldspars, muscovite, quartz, and other minerals were mixed with the clay minerals during deposition in water, but later the carbonates were removed. The weathering profiles developed on the underclays resemble the Wisconsin till.

I. Introduction

For several summers, the State Geological Survey of Illinois has been studying in the field and in the laboratory the zones of weathering developed on the older glacial deposits. Some similarity to the profile of weathering formed under poor drainage conditions on glacial material has been noted in the underclays of Illinois coal in connection with the detailed studies of Pennsylvanian stratigraphy.[1] It has therefore seemed desirable to study the underclays petrographically, to compare them with the weathered zones of glacial deposits, and to test Worthen's proposal[2] of 1866 that these clays were the original soil in which the Pennsylvanian plants grew. This paper partially summarizes petrographic evidence that the features of the underclays were acquired in two stages, (1) by weathering and purification of the clay before and during deposition, and (2) by soil-forming processes operating *in situ* before the deposition of the coal.

II. Profile of Poorly Drained Areas

Leighton and MacClintock[3] recognize four divisions of the weathered zone above the parent material and these constitute "the profile of weathering." Under poor drainage conditions the profile possesses the following characteristics:

Horizon 1, surficial soil; Horizon 2, light plastic leached clay containing resistant silicate minerals; Horizon 3, oxidized clay deprived of carbonates by leaching; Horizon 4, oxidized and unleached clay; Horizon 5, unaltered parent material.

The plastic clay of Horizon 2 on the older drift sheets is called gumbotil. It is composed of beidellite[4] with albite, microcline, and perthite feldspars

* Published with the permission of the Chief, State Geological Survey of Illinois. Received April 3, 1931. Presented at the Annual Meeting American Ceramic Society, Cleveland, Ohio, February, 1931.

[1] J. Marvin Weller, "Cyclical Sedimentation of the Pennsylvanian Period and Its Significance," *Jour. Geol.*, **38**, 121 (1930).

[2] A. H. Worthen, Geological Survey Illinois, Vol. I, p. 59, 1866.

[3] M. M. Leighton and Paul MacClintock, "Weathered Zones of the Drift-Sheets of Illinois," *Jour. Geol.*, **38**, 28–53 (1930).

[4] Victor T. Allen, "Petrography of the Weathered Zones of Glacial Deposits." (In press.) Abstracted in *Bull. Geol. Soc. Amer.*, **41**, 85 (1930).

so intricately altered that it is impossible to decide where the feldspars leave off and where the surrounding clay begins (Fig. 2*a*). The ferro-magnesian minerals, such as hornblende and epidote, are partially or wholly changed to beidellite-nontronite. In Fig. 3*a* beidellite-nontronite can be seen taking up space formerly occupied by epidote. The alteration starts at the edges and penetrates inward leaving the boundary between the original mineral and the resulting clay extremely irregular, and this furnishes evidence of the formation of clay by weathering processes operating *in situ*. As the profile becomes well developed, the index of refraction of the clay increases with depth as is shown in the mature profile formed on the Kansan till at Fairfield, Iowa (see Table I).

TABLE I

COMPARISON OF THE INDICES OF REFRACTION OF THE UNDERCLAYS AT VARIOUS DEPTHS WITH THOSE OF A MATURE PROFILE ON THE KANSAN DRIFT

	Poorly Drained Profile on Kansan Till Fairfield, Iowa		Underclay No. 7 Coal Chillicothe, Ill.		Underclay No. 7 Coal Peoria, Ill.		Underclay No. 5 Coal Mt. Sterling, Ill.		Underclay No. 2 Coal Ripley, Ill.	
	Depth from surface (ft.)	Index of refraction	Depth from surface (in.)	Index of refraction	Depth from surface (in.)	Index of refraction	Depth from surface (in.)	Index of refraction	Depth from surface (in.)	Index of refraction
Horizon 1—surficial soil			1/2	1.567			1	1.552	1	1.547
Horizon 2—plastic clay with only resistant silicates remaining	1/2	1.542	6	1.567	4	1.562	3	1.552	6	1.547
	2	1.542	8	1.562	8	1.562	8	1.552	12	1.552
	4	1.547	11	1.567	21	1.562	12	1.552	19	1.547
Horizon 3—oxidized material leached of carbonates	6	1.567					17	1.547		
	8	1.577					23	1.552		
	10	1.567								
	12	1.567								
Horizon 4—oxidized calcareous material										
Horizon 5—unweathered parent material			13	1.567	47	1.562				
			21	1.567	8 (ft.)	1.567				

III. Comparison of the Underclay with Gumbotil

In the outcrops of many underclays noncalcareous clays grade downward into calcareous as if they were derived from calcareous clays by leaching. A brown humus zone is present below the coal and resembles Horizon 1 of the poorly drained profile. It passes down into lighter plastic leached clay that has been assigned[5] to Horizon 2. The lower part of the leached clay

[5] See footnote 1, p. 564.

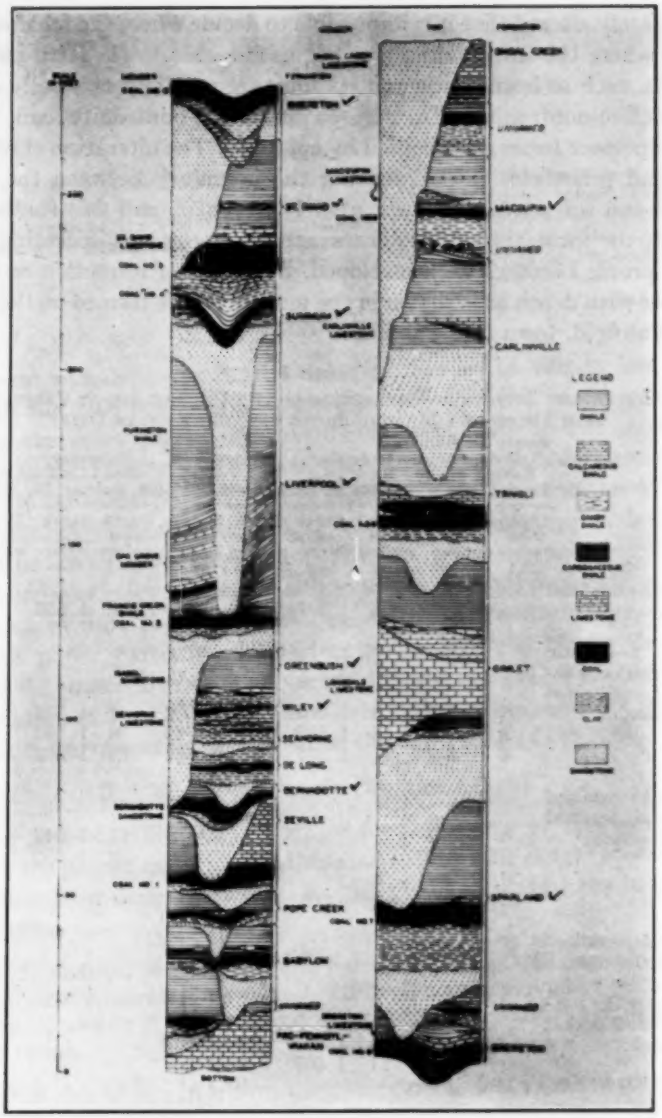

FIG. 1.—Columnar section of the Pennsylvanian of Illinois showing repetition of cycles according to H. R. Wanless. Horizons from which underclays have been studied petrographically are indicated by a check.

and the underlying calcareous clay are stained with iron oxides. The rusty appearance due to them is limited to the outer few inches, and is lacking in strip and shaft mines. Barite and gypsum are associated with it, suggest-

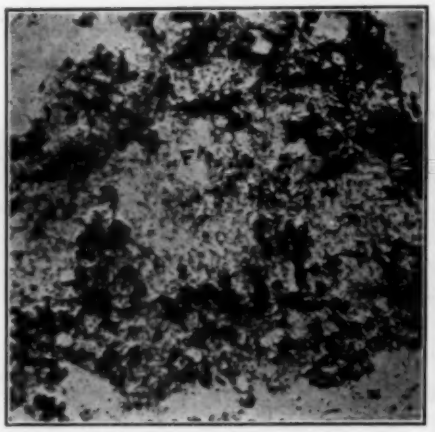

FIG. 2 (*a*).—Feldspar (F) in Kansan gumbotil altered *in situ* to beidellite. Boundary so irregular that it is difficult to decide where the feldspar leaves off and the clay begins. Fairfield, Iowa. × 80.

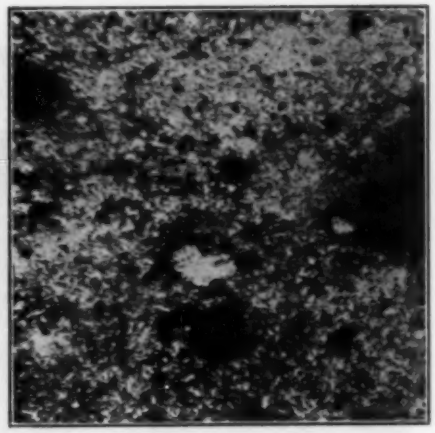

FIG. 2 (*b*).—Fresh andesine feldspar in underclay one-half inch below coal No. 7. Boundary sharp. Chillicothe, Ill. × 80.

ing that it is due to the oxidation of pyrite and is not necessarily connected with the profile.

The underclays, which will be mentioned, have been selected from a larger group, the stratigraphic distribution of which can be seen in the columnar section of the Pennsylvanian prepared by H. R. Wanless (Fig. 1). It is considered that each contributes to the problem here discussed.

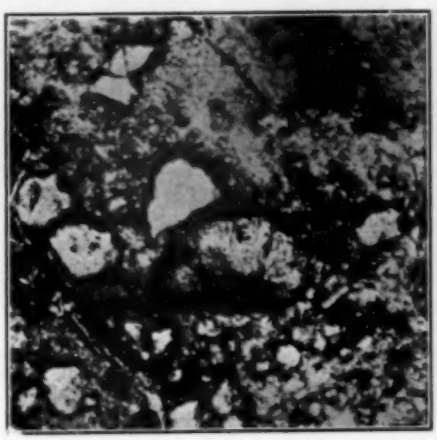

FIG. 3 (*a*).—Epidote (E) altered to beidellite-nontronite. Original outline can be made out, and speck of epidote is enclosed by beidellite-nontronite. Illinoian gumbotil. I. C. cut near Salem, Ill. × 46.

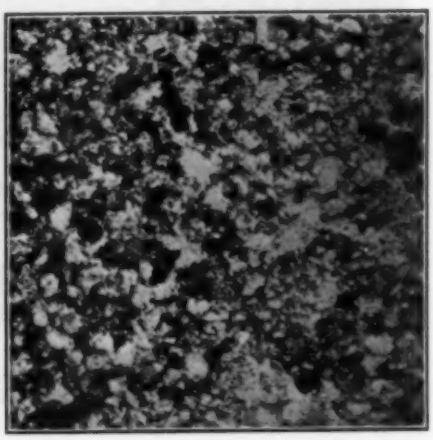

FIG. 3 (*b*).—Biotite (B) in sandy part of underclay of coal No. 4. Near Mt. Sterling, Ill. × 46.

The contact of the humus zone with the coal at the pit of the Illinois Clay Products Company, near Morris, Illinois, appears sharp (Fig. 4*a*), but upon closer examination much carbonaceous material can be seen in

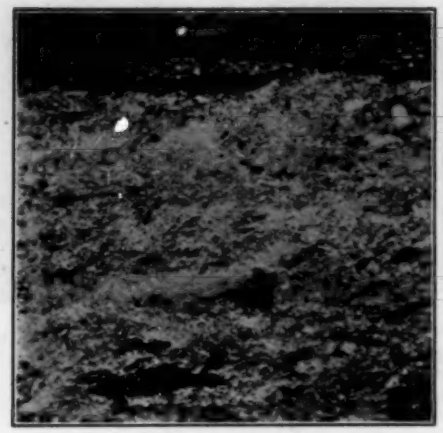

FIG. 4 (*a*).—Contact of Horizon 1 with coal. Pit of Illinois Clay Products Co., near Morris, Ill. × 46.

FIG. 4 (*b*).—Horizon 2. Irregular patch of beidellite enclosing and surrounded by quartz, anauxite, and muscovite. × 46.

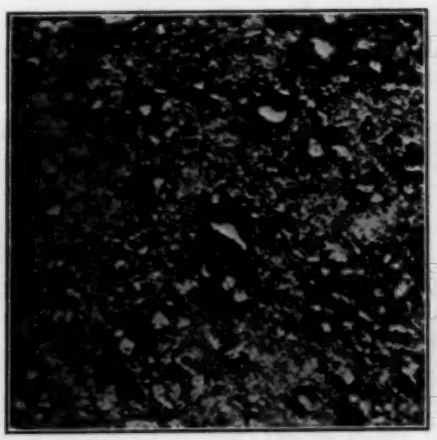

FIG. 5 (*a*).—Noncalcareous underclay 5 in. below coal No. 6. Orient No. 1 Mine, West Frankfort, Ill. Beidellite, quartz, feldspar, and muscovite. × 46.

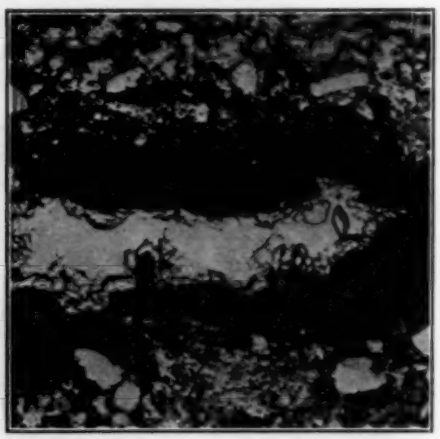

FIG. 5 (*b*).—Underclay 5 ft. below coal No. 6. Orient No. 1 Mine, West Frankfort, Ill. Secondary calcite crystals fill a former cavity near the center. × 46.

the clay and layers of clay are interbedded with the coal. The clay is mainly beidellite and in Horizon 2 it may form irregular patches (Fig. 4*b*) including and surrounded by other minerals, chief of which are quartz, anauxite, and muscovite.

The underclay in Orient No. 1 mine, West Frankfort, Illinois, is leached for four feet below coal No. 6, and is composed of beidellite, quartz, muscovite, and feldspars. It rests upon a clay containing cavities filled with secondary calcite crystals (Fig. 5*b*), which are best explained by the deposition of material leached from above. Similar action has been described in connection with the profiles of weathering on glacial drift, and this constitutes evidence of the activity of soil-forming processes at least to that extent. The processes have not gone far enough to remove the basic feldspars as they have in the gumbotil. Fresh andesine feldspar with sharp boundaries (Fig. 2*b*) is present within one-half inch of No. 7 coal near Chillicothe. The clay surrounding it has about the same percentage of fluxes as in the gumbotil. If the removal of the fluxes were due to leaching *in situ*, the feldspars should be altered like those in the gumbotil. Since they are not, the alternative is that the clay was purified before deposition, that fresh feldspars were mixed with the clay during deposition, and that the soil-forming processes which followed were not sufficiently intensive to affect the feldspars. The latter possibility is supported by a study of the indices of refraction of the underclays at various depths below the coal. Four underclays are listed in Table I, and none shows the marked increase in refractive index with depth that the profile on Kansan till possesses. A decrease in alkalis or iron in the nontronite member decreases the refractive index, and it would appear from the uniformity in refractive indices of the underclays that profile development has not progressed as far as that on the Kansan till nor far enough to affect the clay minerals materially nearer the coal more than those at greater depth in the profile.

Under the better drainage conditions of some glacial drift, beidellite[6] is carried downward and deposited in cracks and cavities with its cleavage plates parallel to the sides of the openings (Fig. 6*b*). The better drainage conditions afforded by the greater porosity of the Bernadotte sandstone would be expected to allow some downward movement of the beidellite in the sandy underclay below the coal near Bernadotte, Illinois. Thin sections at two-inch intervals were prepared and the most favorable indication of this action is shown in Fig. 6*a*. It is apparent that the process has only started.

The underclay below a two-inch coaly streak representing the horizon of No. 4 coal near Mt. Sterling is sandy and contains greenish biotite which persists within a short distance of the coal. Under subtropical weathering biotite is leached and changes to anauxite.[7] Leaching in this underclay has not been adequate to remove the coloring matter from the biotite.

[6] See footnote 4, p. 564.

[7] Victor T. Allen, "Anauxite from the Ione Formation of California," *Amer. Mineral.*, 13, 148–52 (1928); "The Ione Formation of California," Univ. of Cal. Pub., *Bull. Dept. Geol. Sci.*, 18, 387–88 (1929).

Furthermore, it can be observed that the percentage of biotite and heavy minerals (specific gravity greater than 2.9) is more closely related to texture

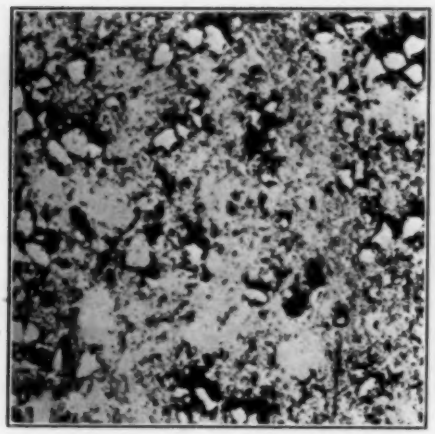

FIG. 6 (*a*).—Vertical streak of beidellite in Bernadotte sandstone composed of quartz and a few grains of feldspar, near Bernadotte, Ill. × 46.

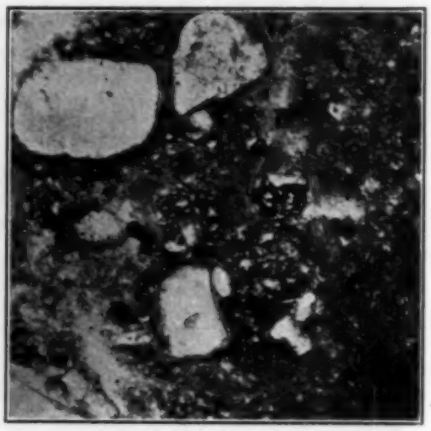

FIG. 6 (*b*).—Beidellite with cleavage plates parallel to the sides of a crack in a well-drained profile on Wisconsin till, near Urbana, Ill. × 46.

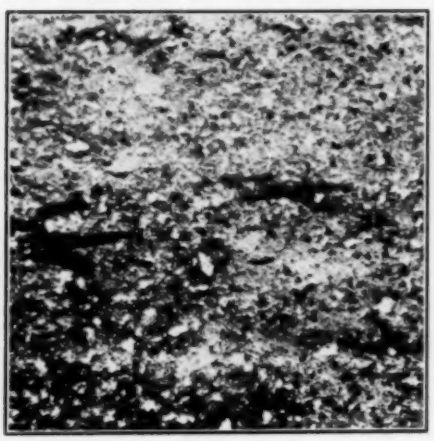

FIG. 7 (*a*).—Carbonaceous material in underclay 12 in. below coal at the pit of Illinois Clay Products Co., near Morris, Ill. × 46.

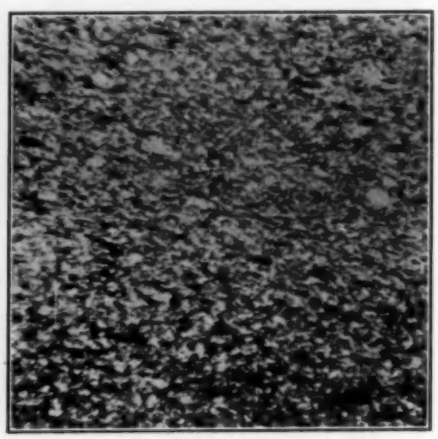

FIG. 7 (*b*).—Fluvatile carbonaceous clay overlying auriferous gravel at Independence Hill, Calif. × 46.

than to the depth below the coal, for it is higher in silt and sand than in clay. This suggests that the conditions of deposition and not weathering are the controlling factors.

IV. Conditions of Deposition of the Underclays

Weller[8] and Wanless divide the section of the Pennsylvanian strata according to cycles of sedimentation. The typical cycle begins with a channel sandstone that grades upward into sandy shales and underclay which is overlain with coal. This part of the cycle is nonmarine. The shales and limestones overlying the coal are marine and complete the cycle. The repetition of cycles in the Pennsylvanian of Illinois arranged by H. R. Wanless is shown in Fig. 1. According to this concept the underclays are continental deposits intimately associated with fluvatile sandstones and shales. There is, however, the question as to whether the underclays also are of fluvatile origin and whether their petrographic features throw any light on the conditions of deposition. For comparison a photomicrograph of the underclay near Morris is placed beside one of a clay from Independence Hill, California, that was undoubtedly deposited by a stream, for it overlies the auriferous gravels filling a stream-cut channel high up on the slope of the Sierra Nevada (Figs. 7*a* and 7*b*). The texture is enough alike that this feature offers no difficulty in accepting streams as the agent of deposition of some underclays. Clays deposited in the valley-flat environment may be as uniform and fine grained as those containing marine fossils and accumulating under delta or true marine conditions. The limitation of the environment must be based largely upon field evidence. A number of features, however, suggest that many underclays accumulated in water. Lenses of quartz like those of water-deposited sediments are common (Fig. 8*a*) and account for the high silica content of some underclays. Carbonaceous particles (Fig. 7*a*), which may resemble small twigs and may be present five or more feet below the coal, are more easily explained and would have had a better chance of preservation if they had been washed in along with the clay. The most convincing evidence is exhibited by the flattened clay pellets, up to one-eighth inch in length, composed of beidellite enclosing quartz and other minerals (Figs. 8*b*, 9*b*), for water seems to be the sole agent capable of fashioning these pellets. Similar structures may be observed in the thin partings of some coal seams, such as the Blue Band of Coal No. 6 in Illinois (Fig. 9*a*), and limit the explanations which have been offered for the origin of the partings.

The texture of the Blue Band is not that of an altered volcanic ash[9] as some advocate. Wind deposition would not account for the pellets unless the material fell into water and, even so, the partings should thicken toward

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[8] J. Marvin Weller, *Jour. Geol.*, **38**, 102–35 (1930).

[9] C. S. Ross and E. V. Shannon, "The Minerals of Bentonite and Related Clays and Their Physical Properties," *Jour. Amer. Ceram. Soc.*, **9**, 77–96 (1926); C. S. Ross, "Altered Paleozoic Volcanic Materials and Their Recognition," *Bull. Amer. Assn. Petroleum Geol.*, **12**, 143–64 (1927); Victor T. Allen, "Altered Tuffs in the Ordovician of Minnesota," *Jour. Geol.*, **37**, 239–48 (1929); "Triassic Bentonite of the Painted Desert," *Amer. Jour. Sci.*, **19**, 283–88 (1930).

the source and this has not been observed. It may be reasoned that the partings and the underclays contain similar structures because they formed under the same conditions.

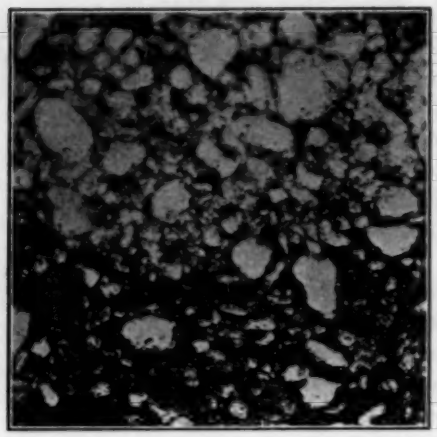

FIG. 8 (*a*).—Lens of quartz in underclay at pit of Illinois Clay Products Co., near Morris, Ill. × 46.

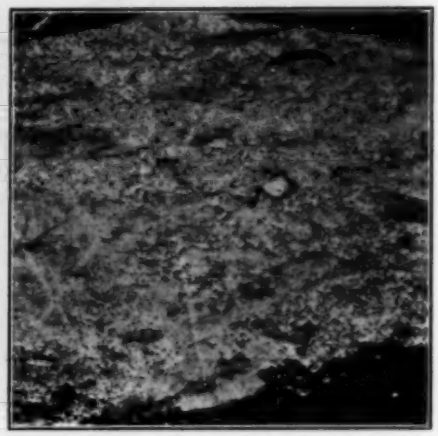

FIG. 8 (*b*).—Large light area is a flattened clay pellet of beidellite including quartz and anauxite. Pit of Illinois Clay Products Co., near Morris. Ill. × 46.

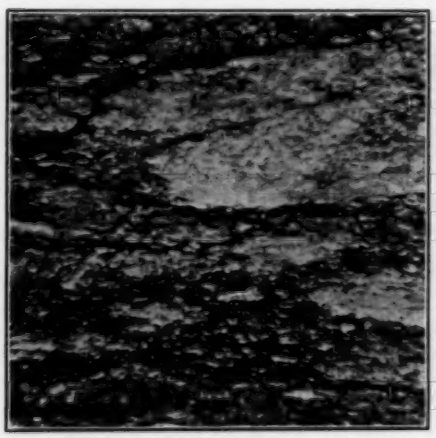

FIG. 9 (*a*).—Blue band parting in No. 6 coal, Franklin County, Ill. Light areas are flattened clay pellets. Dark line is a rootlet. × 46.

FIG. 9 (*b*).—Pellet structure in underclay below coal No. 2 near Ripley, Ill. × 35.

In a recent publication[10] Boswell reports experiments in which the co-precipitation of colloids in fine sediments was facilitated by the presence of

[10] P. G. H. Boswell, "The Action of Colloids in Precipitating Fine-Grained Sediments," *Geol. Mag.*, **67**, 371–81 (1930).

humic acids, and the rapidity of fall was dependent on the concentration. During flocculation and settling, grains were entrapped and the result would appear much like the Illinois underclays. In Pennsylvanian times with large areas of vegetation undergoing chemical changes, ample humic acids would be available. In the back waters of streams or in broad basins formed under suitable topographic conditions, colloidal solutions of purified clay would be precipitated when the requisite concentration of humic acids was reached. Thin layers of wide extent would be due to uniform distribution of colloidal material taking place within the basin as the concentration of humic acid was increasing and thick layers would be due to the maintenance of conditions favorable to accumulation. Deposition would cease when no sediments were being furnished by the land areas or when humic acid concentration was too dilute, for the waters of the basins would be affected by each new inlet or outlet. Minerals of unusual size or composition could be added by the wind or floated out on masses of jelly-like clay as is being observed in connection with the studies of recent sedimentation. Modification of the conditions would make possible the explanation of all the observed primary features of the underclays.

V. Conclusions

Illinois underclays are mainly potash beidellite purified before deposition under the warm climatic and nearly flat topographic conditions of the Pennsylvanian. During deposition in water, feldspars, muscovite, quartz, and other minerals were mixed with the clay minerals. Later leaching of the upper horizons by soil-forming processes has resulted mainly in a removal of the carbonates. The profiles of weathering developed on the underclays are very youthful, more like those on the Wisconsin till than those on the Kansan or the Illinoian.

Acknowledgment The writer takes this opportunity to thank M. M. Leighton, H. R. Wanless, J. Marvin Weller, J. E. Lamar, and other members of the State Geological Survey of Illinois whose assistance has been most valuable in carrying on this investigation.

Dept. of Geophysics
Saint Louis University
Saint Louis, Mo.

A RELATION BETWEEN THE PER CENT ABSORPTION, THE MODULUS OF RUPTURE, AND THE ELECTRICAL CONDUCTIVITY OF BUILDING BRICK*

By Rodney C. Lewis

ABSTRACT

A relation between the per cent absorption and the electrical conductivity of building brick has been found which can be expressed by the empirical equation

$$(B - A)I = K$$

Where B = most probable maximum per cent absorption
A = per cent absorption by weight
I = current in microamperes
K = a factor of proportionality

Likewise, a relation between the modulus of rupture and the conductivity is of the form

$$(M - K_1)(I - K_2) = K_3$$

Where M = modulus of rupture
I = current in microamperes
K_1 = most probable minimum strength
K_2 = current which flows due to presence of conducting materials and insensible voids
K_3 = a constant of proportionality

The constants of the two equations may be evaluated to give the following equations:

$$(23 - A)I = 16$$
$$(M - 760)(I - 0.40) = 430$$

These relations, which were developed from tests on building brick, can be readily applied to other forms of structural silicates.

I. Introduction

Engineers in devising means of testing the strength of materials are more readily turning to indirect methods which do not involve testing to destruction. The use of electricity in these tests has been limited largely to auxiliary recording equipment, although there are magnetic means of testing welded joints with a small exploring coil, and X-rays are used to determine the presence of flaws in castings. It is the purpose of this paper to present a direct application of electricity to the determination of the mechanical properties of building brick.

Heretofore, little work has been done directly in this field, although data on the electrical and mechanical properties of insulating materials are in abundance. It must be noted, however, that the materials whose electrical properties are best known are relatively pure substances such as porcelain, glass, quartz, and mica. On the other hand, the ceramic engineer has dealt largely with clay products whose manufacture and composition are far from uniform. It is only in the design of porcelain insulators, lightning arrestors, and the use of refractories in electric furnaces where both electrical and mechanical characteristics are considered to any extent. There-

* Extract from the thesis submitted by the author in partial fulfillment of the requirement for the degree of Master of Science in the Department of Electrical Engineering at Iowa State College. Received June 22, 1932.

fore, while there is a wealth of information on ceramic materials available, it is not of the nature to permit a correlation between the electrical and mechanical properties of such common products as building brick.

As to the prediction of the mechanical properties of materials, some work has been done with respect to their electrical resistivities. Attempts to correlate the resistivity of a liquid with its viscosity have proved unsuccessful. This might be expected since the resistance of liquids varies enormously with the admixture of quantities of impurities so slight as scarcely to affect the viscosity. Thus, the addition of 1% moisture to transformer oil is sufficient to reduce its resistivity approximately 50%.

A study has been made of the susceptibility to crack development shown by five different kinds of glass under the action of high potentials.[1] The results indicate that the tendency to crack increases with increasing alkali content of the glass and with increasing electrical conductivity.

Considerable work bearing directly on the conductivity through porous ceramic materials has been done in connection with the newer types of lightning arrestors.[2] The variation of the electrical characteristics with respect to pore size is particularly pertinent to this subject. A rather thorough study of the variation of the resistivity of refractories with temperature has been made in seeking a clay suitable for electrical furnaces.[3] Under such conditions the clay must serve the double purpose of insulator and refractory.

In E. E. Schumaker's work on glass and the behavior of the ceramic type of lightning arrestor coupled with the work of John H. Griffith,[4] the suggestion of the existence of a relation between the electrical conductivity and the mechanical properties of structural silicates is to be found.

II. Procedure

The measurement of the conductivity of the brick was made over a wide range of voltage with as nearly a uniform procedure as possible. A full-wave kenetron rectifier set was used giving a very nearly rectified sine wave of voltage up to 50,000 volts. The circuit is as shown in the wiring diagram, Fig. 1. Figure 2 is a view of the apparatus as set up in the laboratory. The high voltage was supplied by a 10 kilovoltampere, 100,000 volt, center-tapped transformer. The ratio of transformation as determined by calibrated voltmeters and a potential transformer is 226:1, a close agree-

[1] E. E. Schumaker, "Crack Development in Glass under Electrical Stress," *Jour. Amer. Chem. Soc.*, **46**, 1772–79 (1924).

[2] J. Slepian, "New Valve Type Lightning Arrestors," *Trans. Amer. Inst. Elec. Eng.*, **49**, 257–64 (1930).

[3] (*a*) R. M. King, "Electrical Resistivity of Some Ceramic Materials at Elevated Temperatures and a Simple Commercial Method for Its Determination," *Jour. Amer. Ceram. Soc.*, **9**, 343–50 (1926). (*b*) A. V. Henry, "Electrical Resistivity of Refractories," *ibid.*, **7**, 764–80 (1924).

[4] John H. Griffith, "Strengths of Brick and Other Structural Silicates," *ibid.*, **14** [5], 325–55 (1931).

ment with that indicated by the name plate as 227.7:1. This ratio is measured from outside terminals to the center tap.

The high voltage is rectified by means of two kenetron half-wave rectifier tubes having a rating of 25 kilowatts at 100,000 volts each. Since the current can flow only from the filament to the plate, current flows through each tube only during that half of the cycle that the side of the transformer to which the tube is connected is positive with respect to the center tap. Hence, full-wave rectification is obtained. That is, both the negative and the positive loops of the impressed sine-wave of voltage are utilized.

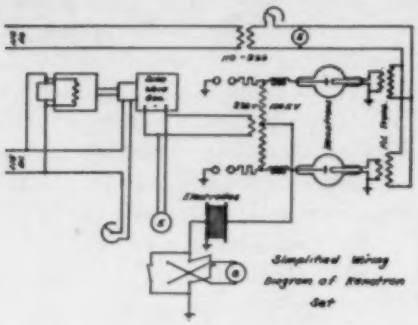

FIG. 1.—Simplified wiring diagram of kenotron set.

As there was no capacity of any appreciable amount in the high voltage circuit, the average direct voltage was taken as the form factor times the product of the ratio of the transformation and the effective input voltage which was measured with a dynamometer type voltmeter. This was considered permissible as the distortion in rectification and the voltage drop in the tubes were negligible. The high-voltage transformer was supplied by a sine-wave alternator, variation in voltage being obtained by controlling the field excitation of the alternator. The input voltage to the transformer was measured and the current through the test sample determined by a sensitive d'Arsonval type galvanometer. Direct and reverse readings of the galvanometer were taken for each value of current in order to obtain an average value in the case of small fluctuations of current and to compensate for the effects of electrostatic fields. Due to the proximity of the high potential electrode, it was found necessary to shield the galvanometer against stray electrostatic fields in order to secure readings at the higher voltages.

FIG. 2.—Electrode and clamping device.

To obtain uniform contact the side of the brick adjacent to the high potential electrode was painted with a mixture of lampblack and linseed oil. It was impractical to paint both sides of the brick in this manner because of the nature of the grounded electrode, which is in the form of a

guard-ring plate. Since the resistance of the air is comparable to that of a brick, the leakage current through the air about the brick was considerable. Surface leakage about the brick would also lead to appreciable error. In order to alleviate this difficulty, the grounded electrode was, as previously mentioned, made in the form of a guard-ring condenser plate. The guard-ring was in reality an aluminum plate 5.5 by 7 inches with a hole in the center, 1.375 inches in diameter. A view of the grounded electrode and the clamping device in which the test brick was held is shown in Fig. 3. The plate was fitted snugly against the brick and connected directly to ground. In the center of the hole in the guard ring was placed the ground electrode, a brass disk 0.875 inch in diameter coated with a paste of lampblack and linseed oil, and connected through the galvanometer to ground. The use of such electrodes insured that the current which was measured by the galvanometer was that which flowed through a definite cross-section of the brick. This afforded a method of determining the volume resistivity with a good degree of accuracy.

The guard-ring type of contact was chosen after experimenting with various types of electrodes such as sharp points, spheres, and small disks. Without a means of diverting the leakage current through the air, the results were hopelessly in error, even as to prohibit obtaining relative values of resistivity. The use of the plates insured a uniform electrical field through the brick such that the current was constrained to follow a direction perpendicular to the face of the brick. The plates were of sufficient size that fringing would not affect the current distribution through the section of brick under test. A further advantage of this type of contact over point or spherical contacts is the possibility of obtaining an average section of the brick.

The samples after being painted were baked in an oven for three hours and then allowed to cool for one hour by which time they had reached room temperature. This procedure gave a reasonably constant moisture content. Since the resistivity of porous dielectrics varies considerably with temperature and moisture content, it was necessary that the conditions of test be uniform.

In measuring the current it was found that at a constant voltage the current decreased with time as has been noted in previous work with refractory clays.[3a] It is undoubtedly due to the polarization of the dielectric. Whitehead[5] attributes the phenomenon to a "sweeping out or removal of the conducting material which on the reversal of polarity is brought back again." To eliminate this effect the obvious solution was to use alternating current as suggested by R. M. King in measuring the resistivity of certain ceramic materials at high temperatures.[3a] Due to the difficulty of measur-

[5] Whitehead and Marvin, "Dielectric Absorption," *Trans. Amer. Inst. Elec. Eng.*, **48**, 304–16 (1929).

ing alternating currents of the order of several microamperes, direct current was used, readings being taken as soon after the application of the voltage as possible. In all cases the voltage was raised to about 30 to 40 kilovolts, just slightly under arc-over voltage, and then reduced in steps of about 3 kilovolts until the minimum readable current was obtained.

III. Results

Insulating materials such as brick do not obey Ohm's law as do metallic conductors. That is, the conductivity instead of being independent of the potential increases rapidly with increasing voltages. Hence, in speaking of the conductivity of a brick it is necessary to specify the voltage at which the value was determined. The problem then is not only to determine the conductivity of the brick but to determine the potential at which the conductivity is a true measure of the mechanical properties and is not masked by the effect of conducting material throughout the body of the brick.

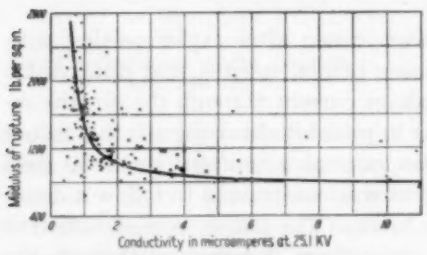

FIG. 3.—Relation between modulus of rupture and conductivity of building brick.

Plotting curves of current through the brick against voltage indicates that the conductivity at higher potentials is more a function of the porosity and, hence, a measure of the modulus of rupture. From a survey of the volt-ampere curves of the test brick, a voltage of 100 volts primary or 25,100 across the sample was chosen. This was the highest potential which could be used in all cases. At times arcing around the brick prevented raising the voltage to high values sufficiently to insure accuracy above 25.1 kilovolts. The value of conductivity at 25.1 kilovolts was taken from the volt-ampere curves in order to obtain a more accurate result. The samples were later rechecked at the single potential of 25.1 kilovolts.

Figure 3 shows the variation of per cent absorption with conductivity. Although the general trend of the data can be predicted from a theoretical consideration, the form of the function relating the absorption to the conductivity is a matter of conjecture. An empirical expression which is satisfactory within the range of the data is given by the equation

$$(B - A)I = K \qquad (1)$$

Where B = most probable maximum absorption
A = per cent absorption by weight
I = current in microamperes
K = a factor of proportionality

That the above equation can not hold for all values of absorption is evident. When A becomes equal to B, the current is infinite, and when A

is greater than B, the current becomes negative. Either condition, obviously, is impossible. It is to be expected that deviations from the curve should exist.

The method used to determine the porosity leads to error since only the contiguous pores can be determined by absorption methods; whereas both sensible and insensible voids contribute to the conduction of current. This could easily lead to serious errors in determining the apparent porosity.

A further source of error lies in the conductivity of the structure of the brick and conducting particles. Moisture is a particular offender in this case unless the humidity is controlled so that the samples are tested under uniform conditions.

Solving for the constants of equation 1 using the data of Fig. 3, the following expression is obtained:

$$(23 - A)I = 16 \qquad (2)$$

When A is zero, there should still be a conduction current due to the insensible or isolated voids and the material of the brick itself. Equation 2 satisfies this condition for when A becomes zero, the current is equal to 0.7 microampere.

The variation of the modulus of rupture of brick with conductivity is shown by Fig. 4 which is a rectangular hyperbola of the form

$$(M - K_1)(I - K_2) = K_3 \qquad (3)$$

Where M = modulus of rupture
I = conductivity in microamperes
K_1, K_2, and K_3 = constants

In equation 3, K_1 may be considered the most probable minimum strength a brick may possess. K_2 represents the current which flows due to the presence of conducting materials and insensible voids. K_3 is a constant of proportionality relating the conductivity and the modulus of rupture. Here again is an empirical equation which satisfies the observed results, but which can be applied only within the limits of the data. It is obvious that neither the current nor the modulus of rupture can be infinite or negative at any time, although the equation indicates that such can be the case.

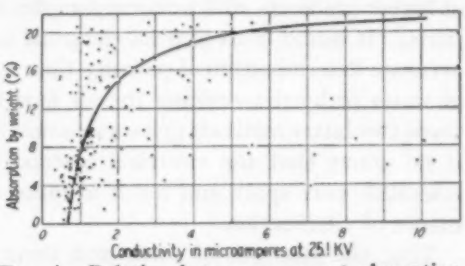

FIG. 4.—Relation between per cent absorption and conductivity of building brick.

Equation 3, however, does satisfy the inferences which may be drawn from Fig. 3 and John H. Griffith's results.[4] Since porosity is the dominant influence in determining both the conductivity and the modulus of rupture, it follows that a relation should exist between the modulus of rupture and

the conductivity. As the modulus of rupture decreases and the conductivity increases with porosity, it is apparent that the strength should be some inverse function of the conductivity. What the function may be is difficult to determine from a theoretical consideration because of the complexity of the nature of conduction through such a substance as brick.

Furthermore, the error in determining the data is such as to render the checking of a theoretical curve difficult unless a vast number of data were available to which statistical methods could be applied. J. H. Griffith places the probable error of a single datum in his work at a maximum of 25%. Thus the values of absorption and modulus of rupture which were taken from his work[4] may be in error by as much as 25% although the error in most cases is from one-half to one-third this amount. The accuracy in determining the conductivity in the method used is largely dependent upon the degree to which the moisture content of the air in the pores of the brick is uniform. The procedure was such that the values of conductivity are accurate within 5 to 10%.

Assuming the relation between conductivity and modulus of rupture to be as given by equation 3, it is possible to determine the constants and to obtain the following expression:

$$(M - 760)(I - 0.40) = 430 \qquad (4)$$

Equation 4 from which Fig. 4 is plotted is seen to satisfy the data reasonably well.

IV. Summary

The relation between conductivity and porosity is one which warrants a more thorough consideration. It is a problem which could well be studied at higher gradients with uniform samples and controlled atmospheric conditions. It would seem that an electrical means would lead to a much more accurate determination of porosity than can be measured by the absorption of water or by determining the air flow through the material. Either of these two latter methods gives a measure of the sensible voids only. There is no doubt that the electrical method could be used to determine the insensible pore space and result in quite an accurate determination of the extent of vitrification.

That the strength of brick and their porosities go hand in hand has previously been shown and has been used as a means to test the strength of structural silicates other than by destruction. The existence of the relation between strength and conductivity provides a means which should result in a surer determination of strength. The existence of this relation may lead to the solution of an interesting problem which has arisen in the Experiment Station of Iowa State College. Work has been carried on to determine a correlation between the strength of 3-foot sewer tile as de-

termined by three-bearing tests and the strength as found when loaded under actual conditions. Heretofore, it has been impossible to select tile of uniform strength with which to perform the tests. The procedure used in determining the conductivity of the brick could easily be extended to determine that of the entire tile, or, by using small electrodes, the pipe could be searched for weak portions. A further application of this procedure lies in testing clay products which have failed in service. The only alternative in such a case is to test other samples (which are of the same group as that which failed) to destruction, a method which can give nothing but dubious results.

Acknowledgment The author wishes to take this opportunity to express an appreciation of his indebtedness to O. A. Brown, Professor of Electrical Engineering, Iowa State College, for the proposal of this problem and his many helpful suggestions in performing the work. The author is further indebted to John H. Griffith, Professor of Experimental Engineering, from whom the test specimens and the data regarding their mechanical strength and per cent absorption were obtained.

DEPARTMENT OF ELECTRICAL ENGINEERING
IOWA STATE COLLEGE
AMES, IOWA

CORRECTION ON PAPER BY ROBERT B. SCHAAL[1]

"After reading the article written from the discussion on 'Sheet-Iron Enamels' presented at the Cleveland Meeting in February, 1931, I see that I owe the SOCIETY an apology for not writing an abstract. The abstract made by the editors is not exactly in accordance with the intent of the article. The abstract should have read as follows:

ABSTRACT

The reasons for the corrective effect on copperheading of a modern double glass ground coat are explained. The boiling tendency of the steel sheets seems to be the primary cause of copperheading, black specks, and a certain amount of fishscale. Pearlite has been found in the steel underneath copperheaded areas.

I wish another statement to be corrected which was overlooked in reading the proof: In paragraph III, page 493, lines 5, 6, and 7, state "It was found that the evolution of gas from the steel sheets is really the underlying cause of practically all enameling difficulties." This should read: "It is believed by the writer that the boiling tendencies of the steel sheets are the underlying causes of nearly all enameling troubles which are not palpably due to poor plant practice."

[1] See *Jour. Amer. Ceram. Soc.*, **15** [9], 490 (1932).

CERAMIC ABSTRACTS[1]

Compiled by the

AMERICAN CERAMIC SOCIETY

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Vol. 11 **October, 1932** **No. 10**

Abrasives

Accurate grinding on aligning bars. Fred B. Jacobs. *Abrasive Ind.*, **13** [8], 9–10 (1932).—Accurate results in any precision grinding operation depend to a great degree on the knowledge of the grinding machine operator. An example of accurately ground work is an aligning bar such as is used in drilling jigs, milling fixtures, grinding fixtures, testing fixtures, etc. E.P.R.

Abrasive lapping machine evaluates metal wear resistance. Charles R. Weiss. *Abrasive Ind.*, **13** [8], 11–12 (1932).—A study to determine the most suitable material and its heat treatment for power transmission chain led to the development of a lapping machine employing abrasive grain as the wearing medium. The data presented are abstracted from a paper presented at the 1932 M-M-M Congress of the A.S.M.E. E.P.R.

Grinding twist-drill points. A. J. Snyder. *Mech. World*, **91** [2370], 536–37 (1932).—Symmetry of form and equality of dimensions are essential features of all correctly ground twist drills, while the lip clearance and point angle must, for best production results, depend upon the composition and condition of the material to be drilled. E.P.R.

Grinding wheel fillers. Henry R. Power. *Metal Cleaning & Finishing*, **4** [7], 415–16 (1932).—To modify the action of the forces of shear and of compression normally at play at the point of contact between the grinding wheel and the work being ground and where the regular grinding compounds can not be used, the wheels are "treated" or "filled" by the abrasive manufacturers. Some of the materials used as fillers are enumerated and the action of impregnated abrasive wheels is briefly discussed. E.J.V.

Use of corundum for the preparation of polishing disks. J. Dorfner. *Z. angew. Chem.*, **45** [19], 334 (1932).—Formerly emery disks were used exclusively for this purpose. By electrical melting of Naxos emery it has been found practical to increase the alumina content until artificial corundum is produced. See also *Ceram. Abs.*, **11** [9], 475 (1932). L.T.B.

Grinding and polishing machines for the glass-polishing shop. G. Bründl. *Diamant*, **52** [14], 226–29 (1930).—After a brief description of the polishing process in general, B. takes up the different kinds of grinding and polishing machines, including all of the special types of machines for special shapes of glass, etc. Illustrated. E.J.V.

Polishing rolls. Victor Litscher. *Diamant*, **52** [28], 452–54 (1930).—A description of some of the different types of polishing rolls used in polishing or grinding glass is given. E.J.V.

Principles of the polishing machine. Anon. *Diamant*, **52** [25], 403–404 (1930).—The principles involved in the operation of various polishing machines used in the glass industry are briefly described. E.J.V.

PATENTS

Gear-grinding machine. C. H. Schurr (Lees-Bradner Co.). U. S. 18,532, July 19, 1932 (reissue).

[1] The abbreviation (*C.A.*) at the end of an abstract indicates that it was obtained from *Chemical Abstracts* by coöperative agreement.

The bold-face number following the journal name is the volume, the issue number is in brackets followed by the page numbers, then the year in parentheses.

Abrading machine. B. W. FREEMAN, L. G. FREEMAN, AND P. H. KOPLIN (Louis G. Freeman Co.). U. S. 1,866,848, July 12, 1932.

Machine for polishing or grinding cam tracks and like sinuous surfaces. J. G. DOUGLAS. U. S. 1,867,213, July 12, 1932.

Honing device. JOSEPH GOULDBOURN AND FRED RICKS (United Shoe Machinery Corp.). U. S. 1,867,623, July 19, 1932.

Portable polishing device. R. A. PONSELLE. U. S. 1,867,629, July 19, 1932.

Grinding wheel dresser. J. A. DAVENPORT. U. S. 1,867,939, July 19, 1932.

Work-supporting attachment for abrading machines. L. E. WOODSEND. U. S. 1,868,266, July 19, 1932.

Sectional grinding wheel. PAUL BUCHEISTER (Sterling Grinding Wheel Co.). U. S. 1,868,492, July 26, 1932.

Mowing machine blade grinder. N. H. HENDERSON (A. C. Parker). U. S. 1,868,603, July 26, 1932.

Gin saw gumming machine. W. B. SMITH. U. S. 1,868,855, July 26, 1932.

Making abrasive articles. E. D. VANCE (Safety Grinding Wheel & Machine Co.). U. S. 1,868,931, July 26, 1932. The process of applying a supplemental binder in liquid form to a porous abrasive article consists in coating the major portion of the article with a covering impervious to the binder, applying the supplemental binder to the exposed portion of the article, and removing the outer covering after the binder has set.

Buffing wheel. J. F. A. DAVIS. U. S. 1,870,239, Aug. 9, 1932.

Lapping machine. H. S. INDGE (Norton Co.). U. S. 1,870,328, Aug. 9, 1932.

Segmental grinding wheel. W. W. GREENWOOD (Norton Co.). U. S. 1,870,449, Aug. 9, 1932.

Machine for the spherical grinding of billiard balls, etc. OTTO KADZIK. U. S. 1,870,571, Aug. 9, 1932.

Relieved screw thread grinding machine. A. M. DRAKE (Pratt & Whitney Co.). U. S. 1,870,718, Aug. 9, 1932.

Multiple spindle automatic screw machine. ANTON GERSTADT. U. S. 1,870,724, Aug. 9, 1932.

Helical gear grinder. ALBERT AEPPLI (H. S. Otto and Henry Escher). U. S. 1,870,764, Aug. 9, 1932.

Manufacture of knives. MAX MAAG AND ROBERT SALOMON (Société d'Études de Machines à Affuter). U. S. 1,870,817, Aug. 9, 1932.

Grinding machine. MAX MAAG AND ROBERT SALOMON (Société d'Études de Machines à Affuter). U. S. 1,870,818, Aug. 9, 1932. M. I. MATHEWSON (Brown and Sharpe Mfg. Co.). U. S. 1,870,857, Aug. 9, 1932.

Roll grinder. R. C. LEWIS AND C. F. SCHNUCK (Farrel-Birmingham Co., Inc.). U. S. 1,871,002, Aug. 9, 1932.

Machine for the spherical grinding of blanks. O. KADZIK. Brit. 375,680, July 6, 1932.

Machine for sharpening saws. E. DU MOULIN AND M. MAYENCE. Brit. 375,850, July 13, 1932.

Grinding or abrading machines. BRYANT CHUCKING GRINDER CO. Brit. 375,980, July 13, 1932. CINCINNATI GRINDERS, INC. Brit. 376,434, July 20, 1932.

Grinding disks for grinding the treads of wheel rims for rail vehicles, etc. G. DÄBRITZ AND E. HANUS. Brit. 376,050, July 13, 1932.

Centerless grinders. CINCINNATI GRINDERS, INC. Brit. 376,271, July 20, 1932.

Buffing and polishing machine. WALKER & HALL, LTD., G. R. SLATER, AND F. MOORE. Brit. 376,394, July 20, 1932.

Lapping machine. W. W. TRIGGS (Pratt & Whitney Co.). Brit. 376,750, July 27, 1932.

Machines for grinding or cutting gear-wheel teeth. GEAR GRINDING CO., LTD., AND R. J. BULLOWS. Brit. 376,911, July 27, 1932.

Machines for polishing sheet material. S. E. WEILL. Brit. 376,936, July 27, 1932.

Dental polishing wheels, etc. CAPON, HEATON & CO., LTD., AND S. A. CHAPMAN. Brit. 376,969, July 27, 1932.

Gear-wheel grinding machines. GEAR GRINDING CO., LTD., AND R. J. BULLOWS. Brit. 377,029, July 27, 1932.

Waterproof emery paper. MINNESOTA MINING & MFG. CO. Ger. 548,273, Feb. 20, 1923; Brit. 194,274. (*C.A.*)

Art and Archaeology

Mosaic glass and its production. V. Sselesnev. *U.S.S.R. Sci.-Tech. Dept. Supreme Council Nat. Econ.*, No. 230; abstracted in *Glastech. Ber.*, **10** [4], 220–21 (1932).—Mosaic glasses are lead glasses of the general composition, $4SiO_2 \cdot PbO \cdot AlK_2O$ up to $6SiO_2 \cdot PbO \cdot AlK_2O$, colored or opacified with antimony-tin oxides or with arsenic oxide. For decorative purposes, the proportion of lead oxide to alkalis may be changed. Colorless opaque glasses are melted first, from which basic glasses with the usual glass pigments, blue, green, gray, violet, red, and yellow, are prepared. By mixing these basic glasses in suitable proportions varied color tones are obtained. Glasses opacified by antimony are produced by mixing a frit of metallic antimony with quartz sand and saltpeter with fresh lead glass, melting at 1000 or 1100° in glasspots, and pouring the melt into water. White tin glasses are produced in the same way. A frit obtained by oxidizing 1 part of metallic tin and 4 parts of metallic lead is melted with lead glass. When preparing the basic colored glass from the opacified glasses, a small amount of the fresh batch is added. Yellow glasses contain Naples yellow (antimonate of lead) as pigment and are obtained by melting a frit of metallic antimony and red lead with a fairly hard potash glass poor in lead. Pink, red, and red-violet glasses are obtained by adding strongly colored ruby glass to the melt and working rapidly. By mixing the basic colored glasses and adding unopacified glasses, less opaque glasses are obtained. The finished glasses are rolled, pressed, or worked into rods. Glasses melted with arsenic oxide are of great importance for mosaic glasses because of their color and degree of opacification. Glasses melted with metallic copper and its oxides have a great variety of color tones due to different methods of cooling. They are all obtained by introducing from 2 to 12% of cuprous oxide and reducing it with iron sulphide, iron borings, sulphur, etc. These copper mosaic glasses are classified as follows: (1) delicately colored opaque glasses produced by copper precipitates and obtained from transparent glasses; (2) "Purpurine," obtained through slow cooling of liquid melts and having red crystals of copper compounds; (3) "Scorzette," copper glasses made opaque with arsenic and whose appearance can be varied through changes in the degree of turbidity and the state of the copper; (4) red copper mosaic glasses produced from tin and antimony white basic glasses. S. describes in detail the materials used, melting requirements, and working methods. M.V.K.

Rivalling the plant world with crystal beauty. Josef Wolf. *Ceram. Age*, **18** [4], 207–11 (1931); see also *Ceram. Abs.*, **10** [10], 676 (1931) and the following abstract. R.G.M.

A glimpse into the inner world of crystalline glazes. Josef Wolf. *Ceram. Age*, **18** [5], 261–63 (1931). R.G.M.

Modern windows in old and new glass. Anon. *Arts & Dec.*, **37** [2], 36 (1932).—Windows of stained and leaded glass are in luminous colors with unusual designs created by Edgar Miller. Illustrated. E.B.H.

Beverage sets. Anon. *Arts & Dec.*, **37** [3], 20–21 (1931).—Colorful striped glass, suitable for every kind of beverage, is combined in attractive services with metal stands and carriers. Illustrated. E.B.H.

Old Chelsea for the modern home. Anon. *Arts & Dec.*, **37** [3], 12–13 (1932).—Chelsea porcelain figures and groups, some as tableware or candlesticks and some simply decorative, are illustrated. E.B.H.

New pottery body stains. B. F. Drakenfeld & Co. *Ceram. Ind.*, **19** [2], 98 (1932).—A new set of colors includes tones of yellow, orange, buff, pink, rose, blue, lilac, and lavender. The colors are said to be fast and will not produce light edges or dark centers. A line of leadless ivory oxide colors for enameling is also being introduced. W.W.M.

Formal and rural decorations for the garden. Anon. *Arts & Dec.*, **37** [2], 40 (1932).—Furnishings for the garden including jars, sun dials, modernistic animals, etc., are illustrated. E.B.H.

Meissen porcelain for Cincinnati. Anon. *Connoisseur*, **89** [369], 359 (1932).—A unique collection of Meissen porcelain formed by Mr. and Mrs. Arthur Joseph has become the public property of Cincinnati, where ceramics have played an important part in the industrial rôle of the community. It is rich in specimens of the best period and has some of the earlier famous red stoneware of Böttger. E.B.H.

Metropolitan Museum shows modern design. Anon. *Ceram. Age*, **18** [5], 251–52 (1931). R.G.M.

Verre églomisé. F. Sydney Eden. *Connoisseur*, **89** [370], 393–96 (1932).—In the Victoria and Albert Museum is a rare example of verre églomisé, which is a process con-

sisting in drawing and painting on the underside of glass and backing the finished picture with metal foil, preferably silver leaf. It is all handwork and distinguishable from the glass pictures of Georgian days. Several early Italian examples of this process are exhibited in the ceramics department of the museum. The colors employed are mostly transparent, sometimes semi-opaque. Gold leaf is used sparingly, the effect of gold being attained by transparent yellow over silver foil. The art in England seems to have disappeared in the 17th Century. Illustrated. See also *Ceram. Abs.*, **10** [5], 321 (1931). E.B.H.

Museum methods in North Germany and Scandinavia. W. SAUNDERS. *Sci. Prog.*, **26,** 687–92 (1932).—A comparison is made between the older method of forming heterogeneous collections of objects which have no relation to each other, and the newer method realized in north Europe of establishing a museum around the intrinsic idea of locality. H.H.S.

Chinese porcelain birds and animals. FRANK DAVIS. *Illus. London News*, **180,** 630–31 (1932).—Photographs of cranes, phoenixes, parrots, horses, dogs, etc., are presented. H.H.S.

Korean art. HELEN FERNALD. *Illus. London News*, **180,** 618–19 (1932).—At Keishu, which was the capital of the kingdom of Silla, and at Pingyang, where a Chinese colony flourished, discoveries of great interest have been made. 12 photographs. H.H.S.

Bottles of 3000 years ago found in old Mizpah tombs. ANON. *Amer. Glass Rev.*, **51** [45], 8 (1932).—Dozens of dainty oil bottles imported from Cyprus before 1000 B.C. and hundreds of juglets, lamps, bowls, and pitchers are among the finds in the last tomb explored in the necropolis of Mizpah. E.P.R.

A prehistoric metropolis: the first Verulamium. R. E. M. WHEELER. *Antiquity*, **6** [22], 133–47 (1932).—Systematic excavation of Verulamium was begun in 1930 and large quantities of pottery have been found. These may be divided into three catagories: (1) imported vessels of Roman (mostly Italic) manufacture, (2) imported vessels of Northeast Gaulish or Belgic manufacture, and (3) coarse imitations of (1) and (2), together with other vessels of coarse fabric, probably from local kilns. Several of these pieces are illustrated and described. The summary of this pottery evidence shows that it has few links with pre-Belgic pottery in England and that for the most part it is similar to the LaTène 111 pottery of northeastern France and the Rhineland as modified by Italian influence. It further emphasizes that the occupation of the excavated area dates from about 10 B.C. to 40 A.D., although the area so far excavated is small. See also *Ceram. Abs.*, **10** [5], 324 (1931). A.A.A.

BOOKS

Babylonian Legends of the Creation and the Fight between Bel and the Dragon. ANON. British Museum, London, 1932. 75 pp. Price 1s 6d. Reviewed in *Times Lit. Supp.*, **31,** 332 (1932).—The Assyrian tablets from Nineveh are now revised from the 1921 edition. H.H.S.

Excavations at Dura-Europos: Third Season Preliminary Report 1929–30. P. V. C. BAUR, M. I. ROSTOVTZEFF, AND A. R. BELLINGER. xiv + 168 pp. 20 plates. Yale Univ. Press, New Haven, 1931. Price $2.75. Reviewed in *Times Lit. Supp.*, **31,** 312 (1932); see also *Ceram. Abs.*, **11** [2], 77 (1932). H.H.S.

Art of the Potter. HARRY BARNARD. Reviewed in *Times Lit. Supp.*, **31,** 315 (1932); for abstract see *Ceram. Abs.*, **11** [8], 439 (1932). H.H.S.

PATENTS

Design for dish. E. B. BEDFORD AND M. G. PARKER (Oneida Community, Ltd.) U. S. 87,326 and 87,327, July 12, 1932.

Design for bottle. RAYMOND GUERLAIN (Guerlain Perfumery Corp.). U. S. 87,342, July 12, 1932. FRANK ARENA. U. S. 87,424, July 26, 1932. M. T. BREKKE (Northam Warren Corp.). U. S. 87,426, July 26, 1932.

Design for glass container. A. G. HAMILTON (J. T. & A. Hamilton Co.). U. S. 87,343, July 12, 1932.

Design for wall sconce. B. L. WATKIN (Pass & Seymour, Inc.). U. S. 87,427, July 26, 1932.

Design for glass pail. F. S. BARBIERS (Hocking Glass Co.). U. S. 87,453, Aug. 2, 1932.

Design for glass tumbler. W. O. BARRY. U. S. 87,454, Aug. 2, 1932.

Design for cooking stove. A. L. BLAKESLEE (Kalamazoo Stove Co.). U. S. 87,456, Aug. 2, 1932.

Design for plate, etc. A. G. HALLGREN (Rosenthal China Corp.). U. S. 87,466, Aug. 2, 1932. J. E. PHILLIPS (Rosenthal China Corp.). U. S. 87,480 and 87,481, Aug. 2, 1932. L. H. BOWN (Buffalo Pottery). U. S. 87,504 to 87,506, Aug. 9, 1932. GEORGE WESP (Rosenthal China Corp.). U. S. 87,555 to 87,557, Aug. 9, 1932.

Design for flask. BEN NASH (Lambert Pharmacal Co.). U. S. 87,478, Aug. 2, 1932.

Design for jar. E. W. FUERST (Owens-Illinois Glass Co.). U. S. 87,512, Aug. 9, 1932.

Design for flushing tank. H. V. KOHLER AND F. G. BROTZ (Kohler Co.). U. S. 87,527, Aug. 9, 1932.

Method of ornamenting chinaware, etc. EUGENE HARDESTY (Mayer China Co.). U. S. 1,868,230, July 19, 1932.

Clay model protector. ALICE GUTSCH. U. S. 1,870,005, Aug. 2, 1932.

Marble-like effects in porcelain, etc. GUSTAV HEUBACH. Ger. 547,972, Aug. 28, 1927. Marble-like decorative effects are produced on porcelain, stone, enamel, glass, etc., by coating with luster paint mixed with combustible liquids such as petroleum, oil, paraffin, tar, etc., and firing. (*C.A.*)

Cements

Action of aluminum sulphate on cement. K. T. KAWASSIADES. *Rev. mat. constr. trav. pub.*, No. 273, pp. 230–31 (1932).—Hydrated sulphate, $Al_2(SO_4)_3 + 18H_2O$, has an injurious action on cement because of the formation of the salt of Candlot (sulpho-aluminate of lime) and, especially, the formation of $CaSO_4$ crystals to the detriment of the lime. Magnesium sulphate has the same action. M.V.K.

Studies of the hydrothermal synthesis of calcium aluminates and silicates between lime and alumina or kaolin. II. S. NAGAI. *Jour. Soc. Chem. Ind.* [Japan], **35** [6], 256–60*B* (1932).—The tests made by N. are described and show that (1) calcium aluminate can be obtained from lime and alumina or aluminum hydroxide by heating under water-vapor pressure, and (2) that kaolin reacts with lime at temperatures as low as 150 to 155°C when heated under water-vapor pressure. For Part I see *Ceram. Abs.*, **11** [9], 479 (1932). M.V.K.

Hydrothermal synthesis of calcium silicates. SHOICHIRO NAGAI. *Z. anorg. allgem. Chem.*, **206** [2], 177–95 (1932); for abstract see *Ceram. Abs.*, **11** [8], 440 (1932). L.T.B.

Chemical composition of the liquid phase of standard Portland cement slip. H. HEIN. *Tonind.-Ztg.*, **56** [50], 632–34 (1932).—An alkali lye supersaturated with calcium hydrate will always form in a cement slip if the clinker originally contained alkalis or if alkalis were later introduced into the clinker or the water. The setting of the cement is caused by reaction between the liquid phase and the components of the clinker. W.M.C.

Results of recent gypsum investigations. V. RODT. *Tonind.-Ztg.*, **56** [52], 659–60 (1932). W.M.C.

Changes occurring within a Portland cement kiln. W. N. LACEY AND H. E. SHIRLEY. *Ind. Eng. Chem.*, **24** [3], 332–35 (1932). R.G.M.

BOOK

Hardening and Corrosion of Cements. (Erhartung und Korrosion der Zements.) KARL E. DORSCH. Julius Springer, Berlin, 1932. Price 13.50 M. *Z. angew. Chem.*, **45** [17], 315 (1932).—Part I of this book treats of the hydration, viscosity, electrical conductivity, temperature of setting, water compounds, and water solubility of Portland and alumina cements. The section of the book on the interaction of Portland and alumina cements is of especial interest to the engineer. Part II of the book deals with the behavior of cements in aggressive waters. L.T.B.

PATENT

Manufacture of brick. GEORGE WITTY (R. T. Harte). U. S. 1,867,641, July 19, 1932. A blast-furnace slag brick consists of granulated blast-furnace slag, cement, calcium chloride, lead borate, and a pigment.

Enamels

Mechanics of enamel adherence. IV. Some studies on the adherence of enamels to cast iron. ARTHUR MCK. GREAVES-WALKER AND R. M. KING. *Jour. Amer. Ceram. Soc.*, **15** [9], 476–80 (1932). **V. A study of enamel-metal contact zones by chemical methods.** GEORGE H. SPENCER-STRONG AND R. M. KING. *Ibid.*, pp. 480–83. **VI. A petrographic, metallographic, and X-ray study of enamel-metal contact zones.** KARL SCHWARZWALDER AND R. M. KING. *Ibid.*, pp. 483–86. **VII. Further studies of enamel-metal contact zones by microscopic and metallographic methods.** G. H. SPENCER-STRONG, J. O. LORD, AND R. M. KING. *Ibid.*, pp. 486–90.

Sheet-iron enamels. A discussion of plant problems. ROBERT B. SCHAAL. *Jour. Amer. Ceram. Soc.*, **15** [9], 490–94 (1932).

Report of the Cast-Iron Research Committee of the Enamel Division. R. R. DANIELSON AND M. E. MANSON. *Bull. Amer. Ceram. Soc.*, **11** [8], 201 (1932).

Blistering of cast-iron enamel: progress report. EMERSON P. POSTE. *Bull. Amer. Ceram. Soc.*, **11** [8], 201–13 (1932).

Discussion of "Blistering of cast-iron enamel." A. I. KRYNITSKY AND W. N. HARRISON. *Bull. Amer. Ceram. Soc.*, **11** [8], 214–15 (1932).

Raw materials of enameling. I. L. STUCKERT. *Ceram. Age*, **18** [4], 212–14 (1931).—S. proposes a new classification of raw materials for enameling into glass-forming materials and accessory materials. The first group includes all of the acid and basic oxides necessary and important for the formation of glass, while under the second heading the materials providing special properties such as bonding power or opacity are included. The various materials are discussed as to their nature and occurrence and from the viewpoint of the special characteristics which each imparts to the product. **II.** *Ibid.*, **18** [5], 257–60 (1931).—S. describes the raw materials for introducing acid and basic oxides and accessory materials into enamels. R.G.M.

Simple analysis of raw materials for the manufacture of enamels. II. ANON. *Emailwaren-Ind.* [Émail], **9** [26], 29–31 (1932).—The several properties of quartz and of borax are discussed. Methods for qualitatively determining the presence of alkaline earth oxides, iron, and alumina, and methods for distinguishing between quartz and kaolin are given. For Part I see *Ceram. Abs.*, **11** [9], 480 (1932). M.V.K.

Color properties of enamels. L. STUCKERT. *Ceram. Age*, **18** [2], 87–90 (1931).—S. discusses colored enamels and considers the optical laws for enamels which are colored by oxides dissolved in the melt. The colors obtained by various metal oxides are listed. The strongest selective absorption of certain colors of the spectrum is obtained by melting cobalt oxide in glasses. The effects of additions of the following oxides are described: chromium, copper, nickel, manganese, and iron. Curves illustrating these effects are included. R.G.M.

Colored enamels. KARL TÜRK. (From the book, The Ready Remedier.) *Emailwaren-Ind.*, **9** [24], 182–84; [25], 190–92 (1932). M.V.K.

Mechanism of atomization of enamel slip. F. R. PORTER. *Ceram. Ind.*, **19** [2], 64–65 (1932).—P. reports a study made to prevent orange peeling of enamel, considering spray gun orifices, air velocities, etc. It was found that increased air velocity or pressure is accompanied by decreased drop size and that the smaller drops make an angular spot instead of round on striking the surface. Causes of orange peeling and the mechanics of atomization are discussed. Orange peeling was found to occur if less than 60 lb. air pressure was used. W.W.M.

Increasing white turbidity in cryolite glasses. ANON. *Emailletech. Monats-Blätter*, **8** [7], 53 (1932).—The earlier methods of producing opaque enamels are briefly summarized and methods of increasing opacity without injuring the gloss, such as adding Deckborolith to the mill, are discussed. See also *Ceram. Abs.*, **10** [11], 756 (1931). E.J.V.

Chemical properties of enamels. L. STUCKERT. *Ceram. Age*, **18** [2], 90–100 (1931).—Consideration of the chemical properties of enamels can be limited exclusively to their resistance to water and dilute acids. Attack by concentrated acids is of importance only in the case of acid-resistant enamels. The solution of glass always consists of two separate processes, (1) a soaking and hydration of the components, and (2) a breakdown of the glass which proceeds according to the solubility of the breakdown products in water. The breakdown of silicates is smaller, the higher is the ratio of silica to alkalis. The solubility of a glass or enamel is highly dependent upon the nature of the constituent oxides. The influence of cooling is described. A table showing the solubility of enamel constituents in water and a chart showing the solubility of enamels in various acids are included. R.G.M.

Enamel science. XVIII. PH. EYER. *Emailletech. Monats-Blätter*, **8** [6], 46 (1932).—The function and chemical action of the ground coat on the steel being enameled are taken up. The reactions taking place and the physical causes for the adherence of the ground coat are briefly outlined. The control of the melting point of the ground-coat enamel and the effect of the firing temperature on the finished product are pointed out. **XIX.** *Ibid.*, **8** [7], 54 (1932).—Some of the defects possible in ground-coat enamels, the causes back of them, and methods of preventing them are taken up. For Part XVII see *Ceram. Abs.*, **11** [9], 481 (1932). E.J.V.

Investigating enamels systematically. L. STUCKERT. *Ceram. Age*, **18** [3], 150–52 (1931).—S. discusses the methods of investigating enamels which have been proposed, pointing out their weaknesses and suggesting new lines of attack. R.G.M.

Acid resistivity of soluble enamel glaze. TOKICHI UCHIDA AND HIDEO SUMIDA. *Repts. Imp. Ind. Research Inst.* [Osaka, Japan], **12** [15], 43 (1932).—A different plan from that of Andrews (see *Ceram. Abs.*, **9** [9], 714 (1930)) is used. (*C.A.*)

Influence of the inhomogeneity of the enamel frit on the finished enamel. ANON. *Glashütte*, **62** [20], 336–37; [22], 379–80 (1932).—Inhomogeneity phenomena are as follows: (1) undissolved particles of raw materials which do not melt because of a too coarse grinding or unsatisfactory mixing; (2) an enamel with strikingly different characteristics of viscosity in different parts (this is due to a separation into component parts of the liquid enamel melt during fritting or to local coolings); (3) precipitations due to a poor firing; and (4) foreign substances appearing in the melt from the batch or kiln installation. M.V.K.

Systematic researches to discover a majolica enamel free from lead. H. J. KARMAUS. *Emailwaren-Ind.*, **9** [19], 146–47; [23], 174–75; [24], 181–82 (1932).—K. describes attempts made to produce majolica enamels free from lead. Eleven different enamel batches are analyzed and discussed. M.V.K.

Cryolite instead of sodium fluosilicate. VIELHABER. *Emailwaren-Ind.*, **9** [26], 198–200 (1932).—When replacing cryolite by sodium fluosilicate in an enamel batch the fusibility and expansion of the enamel and the amount of fluorine must not change. Sodium fluosilicate attacks the refractory lining of the fritting furnace much more strongly than cryolite. The general recommendation is to use one part of sodium fluosilicate for 0.67 part of cryolite. M.V.K.

Enameling of cast iron. BERNARD B. KENT. *Foundry Trade Jour.*, **46**, 243–44 (1932). (*C.A.*)

Vitreous enamel removal process. DIVERSEY CORP. *Brass World*, **28** [6], 125 (1932).—Vitreous enamel is removed by means of special equipment using a material known as "Vitrosol." The de-enameling process is described as a means of reclaiming pieces rejected due to defects in enamel. It is said to be suitable for use in plants where enameling is performed on a production scale, and it is claimed that considerable savings can be effected by means of the "Vitrosol" process. E.P.R.

"Crystal etched" enameling iron. AMERICAN ROLLING MILL CO. *Ceram. Ind.*, **19** [2], 98–99 (1932).—Armco, of Middletown, Ohio, has announced the production of an improved enameling iron to be known as "crystal etched," possessing exceptional bonding qualities. W.W.M.

Equipment for the cleaning of metal. XIX. R. W. MITCHELL. *Metal Cleaning & Finishing*, **4** [7], 389–94 (1932).—Typical equipment and practice employed in drying metal products following cleaning and rinsing operations are discussed. Illustrated. For Part XVIII see *Ceram. Abs.*, **11** [9], 483 (1932). E.J.V.

Enamel defects as faults of construction of the raw ware. H. J. KARMAUS. *Sprechsaal*, **65** [27], 494–96; [28], 516–18 (1932).—A chief requirement for good enameling of sheet metal is the cleanliness of the object. It should be carefully pickled with hydrochloric or sulphuric acids. For good cast-iron enameling the chemical composition of the cast iron is important. Other considerations are the use of different kinds of raw iron, the percentage and quality of cast-iron scraps, and thermal history (highest temperature reached and the casting temperature). The cast iron should be carefully cleaned from sand, rust, and graphite and it should have a silver gray appearance. K. also discusses the influence of shaping in sheet metal and cast iron, mechanical stresses in the ware, the right thickness of walls in sheet metal, thick places in cast iron, too thin walls, sharp convex bends, sharp concave bends, sharp edges, and defects which are difficult to determine in cast-iron ware. M.V.K.

Defects in cast enamels, their causes and prevention. IV. WALTER KERSTAN AND OSKAR KERSTAN. *Emailwaren-Ind.*, **9** [25], 189–90 (1932); for Part III see *Ceram. Abs.*, **11** [8], 442 (1932). M.V.K.

Reasons for the appearance of dirt spots in enamels. H. J. KARMAUS. *Sprechsaal*, **65** [24], 340–41 (1932). M.V.K.

Some enamel defects and their removal. ANON. *Glashütte*, **62** [18], 304–305; [19], 319–20 (1932).—Different defects in enamels and measures taken for their removal are described. M.V.K.

Natural gas as fuel in the enamel industry. FELIX KAINZ. *Chem.-Ztg.*, **55** [88], 846–48 (1931).—For batch furnaces and muffle furnaces which are used almost exclusively in the enamel industry, gas fuel offers definite advantages over solid fuel. Comparing natural gas with other gaseous fuels (water gas, illuminating gas, etc.) we find that the former has the highest calorific value (8600 cal./cu. m.). The amount of air required for complete combustion is correspondingly higher (9.5 cu. m. air for 1 cu. m. gas). Its temperature reaches 1600°C while that of water gas is 1800°. This temperature can be raised by preheating the air used for combustion. The combustion velocity of natural gas is lower than that of water gas, but not of other gases. Its heat density (3000 cal.) is also lower than that of water gas and higher than that of other gases. Recuperation gives a gain in heat equal to 31% of the heat of combustion; this gain is higher than in other gases. In regard to the action of the temperature of combustion on the fireproof furnace lining, natural gas offers possibilities of reducing its temperature by dilution with air or utilization of its high temperature if a lining with a high melting point is used. A mixture of 1 volume of gas and 3 volumes of air is not explosive. J.G.T.

Development of the porcelain enameling industry. F. MCC. BURT. *Ceram. Age*, **18** [3], 147–49 (1931).—B. stresses the increased use of gas in the enameling industry. R.G.M.

PATENTS

Enamel metallic tile. N. J. BURGETT (J. W. Hoehl). U. S. 1,868,815, July 26, 1932.

Method of recovering fluorides from enamel glass smelter gases. G. H. MCINTYRE (Ferro Enameling Co.). U. S. 1,869,019, July 26, 1932.

Apparatus for making glass and vitreous enamels. G. H. MCINTYRE AND R. W. STUART (Ferro Enamel Corp.). U. S. 1,870,636, Aug. 9, 1932.

Production of white opaque enamels and glazes. I. KREIDL. Brit. 375,672, July 6, 1932.

Production of white opaque enamels and glazes, especially sheet-iron enamels. I. KREIDL. Brit. 375,673 and 375,674, July 6, 1932.

Glass

Diffusion combustion and its application to glassmelting. P. Q. WILLIAMS AND C. CONE. *Jour. Amer. Ceram. Soc.*, **15** [9], 501–507 (1932).

Effect of boric oxide on the devitrification of the soda-lime-silica glasses. The quaternary system, Na_2O–CaO–B_2O_3–SiO_2. GEORGE W. MOREY. *Jour. Amer. Ceram. Soc.*, **15** [9], 457–75 (1932).

Volatilization of boric acid during glassmelting. I. I. KITAIGORODSKY AND M. S. FEODOROVA. *Trans. State Expt. Inst. Glass* [U.S.S.R.], No. 1 (1932); abstracted in *Sprechsaal*, **65** [26], 479 (1932).—The volatilization of boric acid during the melting process of a glass of the composition, $5SiO_2 \cdot 1B_2O_3 \cdot 1RO \cdot 1R_2O$, was investigated in regard to viscosity, chemical composition, and the quantity of glass present. The change in viscosity was obtained by replacing 0.25 or 0.50 mol. SiO_2 by Al_2O_3. The influence of the quantity of glass was ascertained from additions of the same glass in crucibles of different capacity (70, 200, 600, and 800 g.) and subsequent analysis. Concerning the influence of the chemical composition of the glasses on the volatilization of boric acid, it was determined that in zinc glasses the evaporation is lowest, while in baryta glasses it is highest. The volatilization in dependence on the viscosity of the glass is lowest in glasses of an average viscosity. Larger quantities of melt produce less volatilization. M.V.K.

Granulated or flaky boric acid; borax in crystals or in grits. LUDWIG SPRINGER. *Glashütte*, **62** [21], 360 (1932).—S. describes investigations made to find out whether flaky or granulated boric acid melts better in a glass batch. The results show that there is no marked difference in the melting of both kinds of boric acid; boric acid used in the form of grits melts easier and therefore should be used in the glass industry. Borax should also be used in the form of grits. M.V.K.

Solubility of lead glasses in water. SHIZUTA MORIYASU. *Jour. Soc. Chem. Ind.*

[Japan], **35** [6], 260–65*B* (1932).—The experimental work of K. Tabata and K. Yegami is described. Conclusions are as follows: (1) For glasses of $z = 0.15$ to 1, $y = 2.8$ to 5.5 $\frac{dw}{dx}$ $y,z>0$, the solubility is increased with the molecular ratio $K_2O:Na_2O$ (k/n) when the molecular percentage of PbO and SiO_2 is kept constant. (2) For glasses of $x = 0$ to 1, $z = 0.15$ to 0.5, $y = 2.8$ to 4 $\left(\frac{dw}{dz}\right)$ $x,y<\left(\frac{dw}{dy}\right)$ x,z or $^1/_3$ $\left(\frac{dw}{dz}\right)$ $x,y'<$ $\left(\frac{dw}{dy'}\right)$ x,z, the solubility is decreased with the molecular ratio, $PbO:SiO_2$ (p/s) when the molecular percentage of K_2O and Na_2O are constant. (3) It is evident from (1) and (2) that the solubility of the glasses is not determined with only the sum of the molecular percentages of K_2O and Na_2O. See also *Ceram. Abs.*, **10** [12], 832 (1931). M.V.K.

Lead glass eliminates danger from X-ray work. R. A. Miller. *Amer. Glass Rev.*, **51** [39], 20 (1932).—The medical and surgical field has suffered many losses due to cumulative effects of Röntgen or X-rays. New glass offers a transparent shield to workers. For many years it has been well known that sheet lead and even transparent glasses having a high lead content are excellent interceptors of the short energy waves emitted by the Röntgen or X-ray tubes. These X-rays are destructive to animal tissue, and too long exposure will produce severe burns. X-ray lead glass as produced in this country by the Pittsburgh Plate Glass Co. is a canary yellow, perfectly transparent glass, which, when compared with the foreign product, is remarkably free from inherent defects such as boil and seed. When compared with the more usual glasses, X-ray lead glass is found to be from four to five times heavier and it shows many other differences from commercial glasses such as plate and window glass. E.P.R.

Use of selenium in the manufacture of glass products. Anon. *Ceram. Ind.*, **19** [2], 72–76 (1932).—The double action of selenium as a colorizer and decolorizer is considered. Some of the literature regarding this metal is reviewed. W.W.M.

Influence of sodium chloride and sodium sulphate on crystallization of window glasses. A. P. Zak and S. I. Iofe. *Sprechsaal*, **65** [26], 479 (1932); for abstract see *Ceram. Abs.*, **10** [11], 763 (1931). M.V.K.

Crystals in a baryta glass. P. Nicolardot and P. Gaubert. *Glastech. Ber.*, **10** [5], 340 (1932); for abstract see *Ceram. Abs.*, **9** [6], 418 (1930). M.V.K.

Outline of the technology of glass. Commercial glasses. J. S. Morgan. *Glass*, **8** [12], 492–97 (1931).—The chief constituents are listed and the requirements of purity are given. In special glasses elements such as lithium, carbon, titanium, vanadium, cerium, and uranium are employed. Special properties imparted to glass by the use of various elements are outlined. Recent researches on thermal conductivity of glass indicate three states in glass through which it passes in cooling from a fluid to brittle condition. The modern tendency to stabilize glass by additions of feldspar, dolomitic limestone, magnesite, or borax is discussed. Advantages of additions of Al_2O_3 up to 2.5% are outlined. Calculations of batches are illustrated. G.R.S.

Batch and the flow of glass. Hugo Hermann. *Glashütte*, **62** [21], 358–59 (1932).—Keppeler found that the beginning of the melting process is due to the formation of eutectic melts. These first melts can be determined exactly from melting diagrams. It was found that the acid alkali silicates, $Na_2O{\cdot}2SiO_2$ and $K_2O{\cdot}4SiO_2$, play an important rôle in the first stages of the melt because of their low melting points of 870 and 765°, respectively. When a quartz grain comes in contact with soda or potash, acid silicates are formed, possibly also through the reaction in solid state. At 900° the melts are liquid and it must be assumed that the quartz grains are surrounded by considerable quantities of easily fusible melt. In the places where this melt comes in contact with additional soda and potash particles, the melting process is at first checked because metasilicates originating in such places have a comparatively high melting point. It must be concluded, therefore, that the melting batch has a spongy structure and that the metasilicates form cells containing liquid acid melts in which quartz grains float. With an increase in the temperature the cells and quartz grains dissolve in the increasing quantity of melt. Lime reacts with quartz and the primary alkali melts during the formation of the glass. Devitrifications show (1) that separate parts of the flow of glass are especially rich in lime, and (2) the low capability of diffusion of lime in glass. The capability of diffusion depends on differences in concentration and when they are lacking the homogenizing of the flow of glass proceeds slowly. The suitability of rocks containing alkalis in glassmelting is discussed and difficulties appearing when using them are explained. According to H. they are due to diffusion processes appearing during melting. The dissolving capability of silica is also discussed. M.V.K.

Batch. F. H. ZSCHACKE. *Glashütte*, **62** [21], 356–58 (1932).—Z. discusses the effect of each component of the properties of the finished glass on the working properties of glass batches. M.V.K.

Origin and behavior of bubbles and streaks in a batch and flowing glass melt. HANS JEBSEN-MARWEDEL. *Glastech. Ber.*, **10** [4], 257–79 (1932).—This is the original reference; for abstract see *Ceram. Abs.*, **11** [2], 88 (1932). M.V.K.

Experimental studies on form and growth of cracks in glass plate. M. HIRATA. *Sci. Paper Inst. Phys. Chem. Research* [Japan], Vol. 16, No. 322 (Sept., 1931).—H. calculated the surface energy of cracks produced in plate glass and compared it with the potential energy due to thermal contraction of the plate. Discrepancies between these two quantities are attributed to residual strain in the glass. The number and sinuosity of the cracks vary with the temperature of the plate and its rate of submersion in the water. Cracks produced in the plate by several methods of heating and by bending are essentially the same, *i.e.*, at the tip of the original short crack two cracks branch out, at the tips of these two more cracks branch out, etc. Different methods of heating, however, produce systematically modified patterns of cracks. A suggestion on the mechanism of the growth of cracks is proposed. W.W.M.

Problems of the glassy state. EDWIN BERGER. *Diamant*, **53** [10], 145–46 (1931); for abstract see *Ceram. Abs.*, **10** [8], 550 (1931). E.J.V.

Processes taking place in the softening interval of glasses. G. TAMMANN. *Glashütte*, **62** [24], 410 (1932).—The physical properties of glasses, in their dependence on the temperature, show anomalies in the softening interval. The coefficient of expansion, the specific heat, and other properties increase more rapidly at a definite temperature interval than at lower or higher temperatures. This temperature interval in which glass loses its brittleness can be determined in different ways. It coincides with the temperature of the turning point on the curves of the coefficient of expansion and of the specific heat. This definite temperature is characteristic for every vitreous amorphous substance. It is an important constant like the melting point of a crystal. M.V.K.

Hydrolytic stability of chemical glassware. F. H. ZSCHACKE. *Chem.-Ztg.*, **55** [60], 580–81 (1931).—Official requirements for chemical glassware divide all glasses into five classes according to the amount of glass material leached out by boiling water. A discussion of the properties of glasses of all classes leads to the conclusion that only those belonging to the three upper classes, leaving a residue of not more than 500 mg./1000 Na_2O in 1 hr., can be used for laboratory glassware of all kinds. Other kinds are efflorescent in moist air, can not resist usually employed reagents, and are especially unfit for measuring apparatus as drops of the measured liquids often adhere to their inner surface and can be removed only with difficulty. They can not be used for autoclaves, as the conditions of temperature and pressure affect them seriously. J.G.T.

Ultra-violet transparency of thin blown window glass. HANS KLUMB AND TH. HAASE. *Z. Physik*, **75** [5–6], 322–27 (1932).—Pyrex glass is blown to a thickness of 10 μ; it will stand differences of pressure of 1 atmosphere or more. This glass is transparent to wave-lengths of 1850 Å. It has the same degree of transparency as quartz glass 1 mm. thick. The transparency of other commercial glasses is given. L.T.B.

Glass characters relative to composition. S. R. SCHOLES. *Fuels & Fur.*, **9** [12], 1401–1404 (1931).—S. discusses the relationship between the chemical composition and physical properties of glass and gives a short description of the development of glass-making. He explains the additive theory of glass components and considers the effect of the principal oxides on the character of the glass. The effect of alkalis is taken up at length. E.J.V.

Compounding of glasses for specific purposes. S. R. SCHOLES. *Fuels & Fur.*, **10** [3], 221–22 (1932).—The characteristics of glass in general are rigidity, transparency, refracting power, electrical resistance, and chemical stability. S. discusses the essential characteristics of glass intended for a specific purpose, such as window glass, optical glass, bottles, tableware, technical glass, etc. E.J.V.

Bands of rare metals and glasses colored by them. JOSEF WOLF. *Sprechsaal*, **65** [27], 491–92 (1932).—In previous investigations, W. detected the presence of rare metals in dilute solutions of rocks through stripes in the colored band of the spectroscope; the same method was used for investigating glasses containing rare metals. The color tone of a neodymium glass was blue or red according to the illumination. Uranium glasses have a beautiful range of color; glasses colored with gold, silver, or copper show blue to red color tones according to the grain size of the material precipitated. The reasons for this changing color impression of different glasses are not the same. In uranium and dichromide glasses (glasses containing potassium dichromate)

they are due to fluorescences. The grain size of the material precipitated stipulates the color tone of gold, silver, and copper glasses. The play of colors of glasses colored with rare metals is due to metameric colors; this is conditioned by stripes in the colored bands. In strongly saturated solutions, the stripes are generally not clear and appear as wide faded bands or shadows. When diluted, the stripes become more visible but disappear gradually with a stronger dilution. A hard porcelain glaze and an underglaze for hard porcelain containing neodymium were also investigated. About 3% of neodymium phosphate was present in the glaze and about 30% in the underglaze. The color tone of the former was light blue in daylight and soft pink with artificial light; the latter had a stronger color tone. The surfaces when observed through the spectroscope showed the characteristic stripes of neodymium. W. concludes that these investigations show that it is possible to detect rapidly the presence of rare metals in glasses, glazes, and underglazes with a spectroscope. Photos show bands of ceric oxide in saturated and dissolved solutions, didymium solutions, solutions of neodymium nitrate and sulphate, neodymium glasses, praseodymium glass, didymium glass, and glasses colored with neodymium and didymium. M.V.K.

Coloring glasses with cadmium sulphide. M. Babille and A. Granger. *Chim. & ind.* [Special No.], pp. 481–82 (March, 1932); for abstract see *Ceram. Abs.*, **11** [7], 408 (1932). (*C.A.*)

Copper blue glasses and glazes. E. Berdel. *Ceram. Age*, **18** [3], 153–54 (1931); see also *Ceram. Abs.*, **10** [12], 821 (1931). R.G.M.

Chemical decoloration of glass. Johannes Löffler. *Glastech. Ber.*, **10** [4], 205–11 (1932).—This is the original reference; for abstract see *Ceram. Abs.*, **11** [2], 92 (1932). M.V.K.

Fluorescence of colored glass. W. R. Lester. *Diamant*, **53** [32], 503 (1931); for abstract see *Ceram. Abs.*, **10** [6], 416–17 (1931). E.J.V.

Production of a lapis-lazuli effect on glass. T. J. K. *Diamant*, **52** [8], 133 (1930).—A brief description of the chemical treatment to obtain a lapis-lazuli effect on glass is given. E.J.V.

A good inexpensive decoration technique for glass. Otto Herfürth. *Diamant*, **53** [35], 550–51 (1931).—H. proposes a method of decorating glass by etching it cold, pressing aluminum or variegated materials into the roughened surface, and finally japanning the whole to hold the decorative materials in place without firing them in. E.J.V.

Advance in the field of the production of safety glass. Anon. *Glashütte*, **62** [20], 330 (1932).—By means of a special thermal treatment (sudden cooling) of a normal crystal plate glass without changing its composition, new properties are given to it, chiefly an exceptional hardness. Such a glass plate crumbles into pieces (of the size of a pea) which have no sharp edges. It is claimed that this discovery will greatly influence the problem of nonsplintering glass. M.V.K.

Importance of the softening process in safety-glass manufacture. Th. Pesch. *Chem.-Ztg.*, **55** [97], 935 (1931).—It is important to keep the foil in the triple layer glass-foil glass at the proper degree of stickiness. Immersing in a solvent is insufficient; a mixture of two liquids, one a solvent, the other a dilution agent, is better. Keeping the foil in this solution for too short a time diminishes duration of the glass, while keeping it too long produces the so-called ripples, *i.e.*, dispersion of light and imperfect transparency. Polarized light shows the structure of the foil, acetylcellulose being often inhomogeneous. The conditions of softening can be represented by a diagram in which every type of foil occupies its space defined by temperature and concentration. J.G.T.

Problems of safety-glass manufacture. Th. Pesch. *Chem.-Ztg.*, **55** [75], 730–31 (1931).—The glass employed should have a high elasticity in comparison with ordinary glass. The finished product should be clear, free from bubbles, resistant to temperature, and absolutely transparent. The intermediate layer is made of celluloid, acetylcellulose, or artificial resin which is chiefly employed in Germany. It gives the clearest foil and its stickiness is excellent, but its stability remains to be proven, as the product is new. It seems to be satisfactory only within a limited temperature. The edges of the plate hold together well. The other two kinds of binding material can easily withstand a low temperature, but not the high temperature of tropical countries. The sun's rays slowly produce a yellow coloration which can be prevented by the addition of urea. Though official methods of testing safety glass are still lacking, some tests usually employed are described. J.G.T.

Testing safety glass. Martin Abraham. *Sprechsaal*, **65** [25], 455–57; [26], 472–75 (1932).—A. describes (1) the testing of the intermediate layer; (2) splintering

safety, (*a*) falling test; (3) phenomena of cracking; (4) measurements of the splintering safety; (5) requirements on the basis of tests; (6) tests with varied height of the fall; (7) influence of the natural weathering, (*a*) visible changes in safety glass, (*b*) discoloration of safety glass, and (*c*) splintering safety after weathering; (8) supplementary laboratory experiments, (*a*) cold, (*b*) heat and humidity, and (*c*) light; and (9) resistance of safety glass to uniform pressure. M.V.K.

Manufacture of nonsplintering glass. HELMUT MERTENS. *Diamant*, **54** [1], 3–4 (1932).—A brief description of the production of nonsplintering glass and its properties is presented. Illustrated. E.J.V.

Shatter-proof glass. W. O. *Diamant*, **53** [12], 177–78 (1931).—Some of the different methods of preparing shatter-proof glass and its properties are discussed. E.J.V.

Double-pane insulation glass. ANON. *Arch. Forum*, **57** [1], 14 (1932).—Consisting of two layers of glass with a sealed air space between them, a new window glass has been developed which offers heat and sound insulation and resistance to frost and moisture. Since this glass saves from 40 to 63% of the heat lost through windows, its importance in fuel economy and in general air conditioning is obvious. E.P.R.

Mirror production. ARTHUR LAURENT. *Diamant*, **53** [7], 98–99; [11], 161–62; [21], 323–24; [29], 452–53; [32], 516–17; [36], 579–80 (1931).—An empirically scientific treatise with a practical introduction to the development of mirrors is given. The treatment before and after silvering and the importance of proper conditions for producing stable silver coatings are discussed. The hypothesis of chrome plating and the use of amalgam-containing silver solutions, etc., are also taken up. See also *Ceram. Abs.*, **9** [1], 24 (1930). E.J.V.

Silvering glass. DONALD E. SHARP. *Diamant*, **53** [27], 319–21 (1931); for abstract see *Ceram. Abs.*, **10** [2], 112 (1931). E.J.V.

Small mirror silvering. C. F. *Diamant*, **53** [24], 375–76 (1931).—The silvering of mirrors on a small scale and the apparatus used are described in detail. Illustrated. E.J.V.

Defects in the silvering of glasses and their prevention. JACQUES WOLF. *Diamant*, **53** [23], 356–57 (1931).—A summary of the defects possible in the silvering of glasses, their causes, and methods of prevention is presented. E.J.V.

Use of electrochemical by-products in glassmaking. ALEXANDER SILVERMAN. *Glass Ind.*, **13** [8], 129–33 (1932); for abstract see *Ceram. Abs.*, **11** [7], 406; [8], 451 (1932). E.J.V.

Refractory glass. ANON. *Glashütte*, **62** [16], 271 (1932).—A Bohemian glass factory has begun the production of a glass which, besides being refractory, is highly stable to acids and resistant to sudden temperature changes. It is especially adapted for laboratory use. M.V.K.

Glass blocks for building purposes. FRITZ HANSEN. *Keram. Bund*, **6** [45], 301 (1931); abstracted in *Glastech. Ber.*, **10** [4], 237–38 (1932). M.V.K.

Shaping glass. B. MAUDER. *Sprechsaal*, **65** [24], 337–39 (1932).—M. discusses hand shaping, shaping with a model, and the technique of pressed glass. M.V.K.

Manufacture of rolled plate. XXIII. ERNST LUTZ. *Glass Ind.*, **13** [8], 136–39 (1932).—The layout and operation of the Ford Plate Glass Factory at River Rouge is taken up in some detail. The use of rolls for producing plate glass as it flows out of the tank and the best methods of mounting them are taken up. The regulation of the glass issuing from the tank is also discussed. Illustrated. For Part XXII see *Ceram. Abs.*, **11** [9], 487 (1932). E.J.V.

Machinery and methods for the manufacture of sheet glass. W. E. S. TURNER. *Expt. and Research Dept. Glass Tech.*, **13**, 65–121 (1930); *Proc. Inst. Mech. Eng.* [London], pp. 1077–1127 (December, 1930); *Glastech. Ber.*, **10** [4], 221–22 (1932); see also *Ceram. Abs.*, **11** [6], 360 (1932). M.V.K.

Electric heat in glass annealing. R. H. ROGERS. *Amer. Glass Rev.*, **51** [42], 11 (1932).—Strains in glass can be relieved in a short time if the ideal temperatures and cooling curves are followed closely. Electric heat applied in definite zones, each under control, provides means for following the best heating and cooling curves. The conveyer on which the ware passes through has an adjustable speed drive. The heat is distributed uniformly by the disposition of the heating units so that glass passing through close to the walls meets the same conditions as that near the center of the conveyer. A feature of electric heating is cleanliness. There are no products of combustion in the leer and the ware comes out clean and sterile. E.P.R.

Stained glass fired successfully by electricity. FREDERICK E. MAYER. *Nat. Glass Budget*, **48** [11], 3 (1932).—A history of the development of stained glass is given. E.P.R.

Study of pulsating feeders for molten glass. III. Roy E. Swain. *Glass Ind.*, **13** [8], 133–36 (1932).—Special apparatus designed to feed glass to moving molds on forming machines of the continuous type are described. A general summary of the specifications for the feeder as a whole, for the shears, and for the pulsations (needle) is given. Illustrated. For Part II see *Ceram. Abs.*, **11** [9], 487 (1932). E.J.V.

Systematic working of small-coated glasses. Arthur Laurent. *Diamant*, **52** [3], 40 (1930).—The handling of a number of small pieces of glass, such as hand mirrors, etc., in an economical manner is discussed. E.J.V.

Working glass with Widia tools. A. Fehse and B. Kindt. *Glastech. Ber.*, **10** [4], 193–200 (1932); abstracted in *Sprechsaal*, **64** [47], 867 (1931).—The authors describe (1) difficulties appearing during the working of glass, (2) the difference between the working of metal and that of glass, (3) "Widia," a hard metal, as a material for tools for working glass, (4) glass boring, and (5) glass cutting. Illustrated. M.V.K.

Diamonds and their use in the optical and mechanical industries. F. K. Böck. *Optic*, **4** [7], 79–80; [8], 92–93 (1931); abstracted in *Glastech. Ber.*, **10** [4], 223 (1932).—B. describes in detail the boring and cutting of optical glass with diamonds. M.V.K.

Sandblasting and its use for glassware finishing. U. Lohse. *Diamant*, **53** [1], 3 (1931); for abstract see *Ceram. Abs.*, **10** [10], 689 (1931). E.J.V.

Some early records of glassmaking. S. E. Winbolt. *Pottery Gaz.*, **57** [662], 1001–1004 (1932).—A brief summary of the activities of the early glassmakers in the vicinity of Chiddingfold, England, is presented. In 1240 Laurence was supplying glass for Westminster Abbey. Excavations in the district have unearthed apparatus in the form of materials, crucibles, blowpipes, furnaces, etc., and products in the form of window and vessel glass, etc. A rough chronological classification of the glasses found divided them into groups as follows: (1) 1226–1400, (2) 1400–1550, and (3) 1550–1620. In (1) the majority of vessels were of a pale milky green color, semi-opaque, and of a roughish surface; (2) both vessels and window glasses were bluish green with a more burnished surface; (3) the color tended to be of a deeper bluish green, the glass was translucent, and the surface highly burnished. Illustrated. E.J.V.

Old English glass. XXII. Witch balls and pocket flasks. Francis Buckley. *Glass*, **8** [9], 364–66 (1931). **XXIII. Worcestershire glass.** *Ibid.*, **8** [10], 415–17 (1931). **XXIV. Ravenscroft's sealed glasses.** *Ibid.*, **8** [11], 461–62 (1931).—George Ravenscroft, the inventor of British "flint glass," was the first glassmaker to seal or "hall-mark" his glasses. This was first done in October, 1676. Two illustrations show rare glasses of this period with the distinctive seal, a raven's head, attached to the stem. **XXV. Hogarth glasses.** *Ibid.*, **8** [12], 498–99 (1931).—Drinking glasses with very short stems or no stems at all, described as "firing" or Masonic glasses, are discussed and illustrated. **XXVI. Jacobite glasses: Portrait and "Amen" glasses.** *Ibid.*, **9** [1], 14–16 (1932).—Engraved glasses of the early 18th Century are treated. Illustrated. **XXVII. Jacobite glasses: Cycle Club.** *Ibid.*, **9** [2], 58–60 (1932).—The emblems commonly engraved on the Cycle Club glasses were (1) Jacobite or Yorkist rose, (2) the oak leaf, (3) star, and (4) the word "Fiat." Illustrations of 8 rare glasses are shown. **XXVIII. Jacobite and anti-Jacobite glasses.** *Ibid.*, **9** [3], 103–105 (1932).—Engraved glasses of the middle and late 18th Century are described and illustrated. **XXIX. Glasses for the Eastern market.** *Ibid.*, **9** [4], 156–57 (1932).—A discussion is given of the type of glassware exported to the Far East during the 18th Century. **XXX. Glass figures.** *Ibid.*, **9** [5], 197–98 (1932).—Illustrations and descriptions are given of ornamental glass figures made during the 18th and 19th Centuries. **XXXI. A glassmaker's day book.** *Ibid.*, **9** [6], 245–46 (1932).—Of interest in the history of old glass is the day book belonging to John Cookson and Co., compiled during the years 1744 to 1747. Three illustrations of rare glasses are shown. **XXXII. The four-lobed knop or stem.** *Ibid.*, **9** [7], 304–306 (1932).—The development of the four-lobed stem is traced. This type of stem was developed toward the end of the 17th Century by John Greene. Five illustrations of intricate glass are shown. For Part XXI see *Ceram. Abs.*, **11** [6], 359 (1932). G.R.S.

Glass gunpowder. H. Southam. *Notes & Queries*, **162**, 333 (1932).—In an English (the Duke of York's household) list of 1824 there appears the entry: "Glass gunpowder maker, Wilkins & Son." S. makes the inquiry, "What was glass gunpowder?" H.H.S.

Progress of the glass industry in 1931. Oskar Knapp. *Glashütte*, **62** [23], 394–95 (1932).—K. discusses the structure, constituents, and properties of glasses according to (1) "Dependence of properties of glasses on their thermal history," by Berger (*Ceram. Abs.*, **10** [5], 335 (1931)); (2) "Variations in the heating curves of glass," by Tool and Eichlin (*ibid.*, **10** [11], 759 (1931)); (3) "Thermal capability of resistance of glasses,"

by Knapp (*Keram. Rund.*, p. 459 (1931)); (4) "Electrochemical properties of glasses," by Silverman (*Ceram. Abs.*, **10** [9], 629 (1931)); (5) "Electrical conductivity of glasses and silicates," by Schwarz and Halberstadt (*ibid.*, **11** [6], 352 (1932)); (6) "Glass opacified with fluoride," by Knapp (*ibid.*, **10** [9], 631 (1931)); (7) "Refractive indices of some glasses," by Jentsch and Nähring (*ibid.*, **11** [5], 299 (1932)); (8) "Index of refraction of some soda-lime-silicate glasses," by Faick and Finn (*ibid.*, **10** [10], 690 (1931)); (9) "Refractive index of glasses," by Randall and Gee (*ibid.*, **10** [8], 552 (1931)); (10) "Optical properties of didymium glasses," by Moore, Lein, and Sharp (*ibid.*, **10** [5], 337 (1931)); (11) "Permeability of glass to ultra-violet radiations," by Gilard, Swings, and Hautot (*ibid.*, **11** [2], 96 (1932)); (12) "Chemical reasons for decoloration of glasses exposed to radium rays," by Hoffmann (*ibid.*, **11** [4], 237 (1932)). See also *ibid.*, **11** [4], 236 (1932). M.V.K.

Waste products in the glass industry. ANON. *Glashütte*, **62** [23], 393–94; [25], 428–29 (1932).—The use of waste products, *e.g.*, broken glass, cut and cast pieces, wire glass, and defective pieces is discussed. Cases where German glass factories have used these waste products with success are described. M.V.K.

Fourcault installation with two drawing machines. F. STANG. *Glashütte*, **62** [19], 317–18; [20], 333–35; [21], 377–78 (1932).—S. describes in detail the reconstruction of an old glass factory which formerly produced glassware by mouth blowing. M.V.K.

Data for the history of Hungarian glass manufacture. LADISLAUS V. SZATHMARY. *Természettud. Közlöny*, No. 3 (1929); abstracted in *Glastech. Ber.*, **10** [4], 212 (1932).—A short history of the birth (1550) and development of the Hungarian glass industry is given. M.V.K.

Glass factory of Bagneux. ANON. *Glaces et Verres*, No. 23, pp. 2–9 (1931); abstracted in *Glastech. Ber.*, **10** [4], 232 (1932).—The factory manufactures spectacle glass, colored, illuminating, cylinder, and special glasses for perfumes and imitation pearls, and large hollow globes of white and colored glass. M.V.K.

Heat Technical Counsel of the German glass industry. ANON. *Sprechsaal*, **65** [25], 466 (1932).—The report of the Heat Technical Counsel for 1931 deals with (1) old and new cooling leers for hollow glass (Metzger), (2) the problem of waste glass in glass plants (Oppermann), (3) heat-technical investigation on a glassmelting tank (Friedmann), and (4) industrial accounting in glass plants (Goereus). M.V.K.

BOOK

Annealing Glass Leers. (Antempern von Glasöfen.) SILBERT GUSS. Verlag Glashütte, Dresden, 1932. 4.50 Rm. Reviewed in *Glastech. Ber.*, **10** [4], 302–303 (1932).—G. discusses (1) properties of refractory materials, (2) behavior of different parts of the leer during annealing, (3) different ways of annealing, and (4) supervising annealing. M.V.K.

PATENTS

Sheet-glass grinding and polishing apparatus. J. L. DRAKE AND FRANK FRASER (Libbey-Owens-Ford Glass Co.). U. S. 18,533, July 19, 1932 (reissue).

Glass container. C. G. HILGENBERG (Carr-Lowrey Glass Co.). U. S. 1,866,770, July 12, 1932.

Manufacture of nonsplintering glass sheets. G. E. HEYL (Morris Greenhill). U. S. 1,867,009, July 12, 1932.

Method of manufacturing nonscatterable glass. O. S. MARCKWORTH. U. S. 1,867,085, July 12, 1932.

Feeder for glass leers. JULIUS SYLVESTER (Simplex Engineering Co.). U. S. 1,867,389, July 12, 1932.

Method and apparatus for gathering molten glass in molds. E. G. BRIDGES (Lynch Glass Machine Co.). U. S. 1,867,440, July 12, 1932.

Means for transferring bottles from bottle-forming machines. A. D. R. TUCKER (Albion Bottle Co., Ltd.). U. S. 1,867,785, July 19, 1932.

Process of producing laminated glass. G. B. WATKINS (Libbey-Owens-Ford Glass Co.). U. S. 1,867,787, July 19, 1932. W. H. MOSS AND K. H. CRUTCHFIELD (Celanese Corp. of America). U. S. 1,870,018, Aug. 2, 1932. The step of applying an adhesive coating composition containing a urea-phenolaldehyde resin that is compatible with the derivative of cellulose.

Apparatus and method of manufacturing sheet glass. LUCIEN DELLOYE (Soc. anon. des manufactures des glaces et produits chimiques de St.-Gobain, Chauny, et Cirey). U. S. 1,867,940, July 19, 1932.

Colorless glass. GEORG JAECKEL (Sendlinger Optische Glaswerke G.m.b.H.).

U. S. 1,868,065, July 19, 1932. A crucible for the production of colorless glass is characterized in that the refractory material thereof possesses incorporated therein a percentage of neutralized substances in a quantity dependent on the proportion of discoloring substance in the crucible, which neutralizing substances are adapted to withstand the high temperatures to which the crucible is subjected in use without vaporization.

Method of manufacturing wired glass. F. H. Rowe (Clear View Wind Shield Co.), U. S. 1,868,177, July 19, 1932.

Glass building stone, tile, etc. J. W. Janzen (N. V. Glasfabriek "Leerdam," Voorheem Jeekel, Mijnssen & Co.). U. S. 1,868,236, July 19, 1932. A building block formed of vitreous material has a plurality of bearing surfaces on the top side, some of which bearing surfaces are visible when the blocks are placed in a wall and some of which are invisible at such times, and elastic bearing material on the surfaces which are invisible, for receiving the coöperating bearing surfaces of adjacent blocks to prevent fracture of the blocks.

Sheet-glass rolling machine. Carroll Cone (Libbey-Owens-Ford Glass Co.). U. S. 1,868,274, July 19, 1932.

Glass-surfacing machine. J. P. Crowley (Libbey-Owens-Ford Glass Co.). U. S. 1,868,275, July 19, 1932.

Machine for drawing glass into tubes or rods. Robert Salomon. U. S. 1,868,397, July 19, 1932.

Mold for the manufacture of articles in silica glass, etc. Pierre La Burthe (Société "Quartz & Silice"). U. S. 1,868,421, July 19, 1932.

Handling glass articles. James Bailey (Corning Glass Works). U. S. 1,868,480, July 26, 1932.

Heating device for leers. Julius Sylvester (Simplex Engineering Co.). U. S. 1,868,856, July 26, 1932.

Process for the homogenization of glass flux. Rudolf Thum (Montan und Industrialwerke, vorm. J. D. Starck). U. S. 1,868,858, July 26, 1932.

Roller conveyer for glass plates. Lambert von Reis (American Bicheroux Co.). U. S. 1,868,860, July 26, 1932.

Method of manufacturing bifocal lenses. F. B. Watson and Edward Culver (United Kingdom Optical Co., Ltd.). U. S. 1,868,863, July 26, 1932.

Glass-cutting mechanism. J. A. Boush (Blackford Window Glass Co.). U. S. 1,869,044, July 26, 1932.

Method of producing clear vitreous silica. B. F. Niedergesass (General Electric Co.). U. S. 1,869,163, July 26, 1932.

Device for handling and emptying glassmelting pots. Richard Genenger (N. V. Maatschappij tot Beheer en Exploitatie van Octrooien). U. S. 1,869,245, July 26, 1932.

Mold attaching device for glassworking machines. D. E. Gray and D. W. Strait (Corning Glass Works). U. S. 1,869,249, July 26, 1932.

Process and apparatus for the manufacture and leering of glass sheets. Max Bicheroux (American Bicheroux Co.). U. S. 1,869,297, July 26, 1932.

Process and apparatus for the manufacture of rods or tubes of glass, etc. J. A. Cardot (Soc. Anon. Le Pyrex). U. S. 1,869,303, July 26, 1932.

Receiving glass sheets. V. M. Dorsey (American Bicheroux Co.). U. S. 1,869,306, July 26, 1932.

Contact glass. Josef Dallos (Carl Zeiss). U. S. 1,869,366, Aug. 2, 1932.

Multifocal lens. L. W. Bugbee, Jr. (Continental Optical Mfg. Co.). U. S. 1,869,461, Aug. 2, 1932.

Apparatus for handling glassware. G. E. Rowe (Hartford-Empire Co.). U. S. 1,869,622, Aug. 2, 1932.

Machine for forming hollow glassware. L. D. Soubier (Owens-Illinois Glass Co.). U. S. 1,869,920, Aug. 2, 1932.

Means for feeding molten glass. L. D. Soubier (Owens-Illinois Glass Co.). U. S. 1,869,921 and 1,870,210, Aug. 2, 1932.

Closure cap for tumblers, jars, etc. Harry Ingram. U. S. 1,869,938, Aug. 2, 1932.

Method and apparatus for producing sheet glass. Fritz Eckert (W. A. Morton and P. L. Geer). U. S. 1,870,002, Aug. 2, 1932.

Process of surfacing plate glass. J. P. Crowley (Libbey-Owens-Ford Glass Co.). U. S. 1,870,238, Aug. 9, 1932.

Glass furnace. J. L. Drake (Libbey-Owens-Ford Glass Co.). U. S. 1,870,242, Aug. 9, 1932.

Muffle-furnace leer. W. A. Morton (Amsler-Morton Co.). U. S. 1,870,262, Aug. 9, 1932.

Laminated glass apparatus. J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,870,284, Aug. 9, 1932.

Process of making fish bowls. ADDISON JENKINS (D. C. Jenkins Glass Co.). U. S. 1,870,363, Aug. 9, 1932.

Leer loader. C. H. HARDMAN (Hazel-Atlas Glass Co.). U. S. 1,870,506, Aug. 9, 1932.

Process for making composite glass. J. H. SHERTS (Duplate Corp.). U. S. 1,870,693, Aug. 9, 1932.

Glassworking machine. J. P. SCULL (Whitall-Tatum Co.). U. S. 1,870,755, Aug. 9, 1932.

Surfacing process and apparatus. M. A. LAABS (American Optical Co.). U. S. 1,871,123, Aug. 9, 1932.

Process and apparatus for making plate glass. R. L. CLAUSE (Pittsburgh Plate Glass Co.). U. S. 1,871,156, Aug. 9, 1932. W. G. KOUPAL (Pittsburgh Plate Glass Co.). U. S. 1,871,218, Aug. 9, 1932.

Glass-cutting table. J. D. MCLEOD (Pittsburgh Plate Glass Co.). U. S. 1,871,220, Aug. 9, 1932.

Method of coating hollow bodies. A. M. HAGEMAN AND A. F. LINDSTROM (Westinghouse Lamp Co.). U. S. 1,871,367, Aug. 9, 1932.

Pressed-glass comports and cake stands. H. H. PITT. Brit. 375,486, July 6, 1932.

Method and apparatus for fusing silica, etc. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 375,500, July 6, 1932.

Process of melting and refining high borosilicate glasses. CORNING GLASS WORKS. Brit. 375,806, July 13, 1932.

Manufacture and production of compound glass. J. Y. JOHNSON (I. G. Farbenindustrie Akt.-Ges.). Brit. 375,972, July 13, 1932.

Machine for beveling curvilinear glass plates, particularly oval glass plates. ÉTABLISSEMENTS MÉTALLURGIQUES ET FONDERIES SOC. ANON. Brit. 376,215, July 13, 1932.

Process for tempering glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Brit. 376,219, July 13, 1932.

Leers for annealing glass bottles, etc. W. P. GREEN. Brit. 376,333, July 20, 1932.

Manufacture of glass bands, tubes, rods, etc. COMPAGNIE INTERNATIONALE POUR LA FABRICATION MÉCANIQUE DU VERRE (Procédés Libbey-Owens) SOC. ANON. Brit. 376,990, July 27, 1932.

Method of connecting branch pipes to quartz tubes and similar quartz bodies of comparatively great dimensions. JENAER GLASWERK SCHOTT & GEN. Brit. 377,071, July 27, 1932.

Glass. GLASHÜTTENWERKE VORM. J. SCHREIBER & NEFFEN. Austrian 127,520, Nov. 15, 1931. Reflecting glass, for use in lighting installations, comprises opal glass covered on one side with a layer of dark, nontransparent glass and preferably covered on the other side with a layer of crystalline glass. A suitable formula for the nontransparent glass is colorless glass 150, MnO_2 30, CoO 1, S 35, and Na_2SeO_4 10 parts. See following patent. (*C.A.*)

Glass for reflectors. GLASHÜTTENWERKE VORM. J. SCHREIBER & NEFFEN. Ger. 505,947, Sept. 24, 1929. The glass is composed of layers of opal and crystal glass. The opal glass layers are formed by coloring transparent glass by S, Na_2SeO_4, CoO, or MnO_2. (*C.A.*)

Glass. DEUTSCHE SPIEGELGLAS A.-G. Fr. 720,075, July 16, 1931. A glass which is permeable to heat rays and rays of the visible spectrum but absorbs ultra-violet rays contains up to 10% of a mixture of rare earths in the proportion of the natural deposits. (*C.A.*)

Reinforced glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Fr. 720,298, Oct. 14, 1930. Oxides such as Al_2O_3 and boric acid or compounds of oxides such as aluminates or borates are incorporated with glass to increase the adherence of a reinforcing metal to the glass. (*C.A.*)

Glassmaking. PILKINGTON BROS., LTD. Fr. 720,585, July 24, 1931. Means are described for conducting the glass from the rolling apparatus to the annealing furnace. (*C.A.*)

Canal cooling-off furnace for hollow glassware. RUDOLF SCHNEIDER. Ger. 544,726, Dec. 6, 1928. (*C.A.*)

Glass. GUSTAV KEPPELER. Ger. 544,924, April 23, 1930. In glassmaking 75% of the SiO_2 present in the mixture is in finely powdered form. See also *Ceram. Abs.*, **11** [9], 489 (1932). (*C.A.*)

Treating frosted glass to prevent weathering. CORNING GLASS WORKS. Ger. 545,867, June 15, 1930. The glass is washed with aqueous solutions of AlF_3, $Al_2(SO_4)_3$, or Al salts of aliphatic acids. The Al salt is present in amounts not exceeding 750 p.p.m. See following patent. (*C.A.*)

Treatment of frosted-glass articles. ROWLAND D. SMITH (Corning Glass Works). Can. 311,508, May 19, 1931. Frosted-glass articles are washed in an aqueous solution of not more than 750 p.p.m. of AlF_3 to prevent mechanical weakening of the articles caused by weathering. See also *Ceram. Abs.*, **10** [4], 265 (1931). (*C.A.*)

Continuous apparatus for drawing glass tubes or rods. PIERRE A. FAVRE. Ger. 547,135, Nov. 9, 1928. (*C.A.*)

Triplex glass united with cellulose, acetylcellulose, etc. LUDWIG SCHIFF, JR. Ger. 547,801, Jan. 9, 1930. (*C.A.*)

Tempering optical glass. EMIL BUSCH A.-G. OPTISCHE IND. Ger. 548,159, Nov. 26, 1930. Lenses, etc., are floated on a heated metal or salt bath of higher specific gravity than the glass and are then rapidly cooled. (*C.A.*)

Apparatus for making sheet glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Ger. 548,399, June 1, 1930. (*C.A.*)

Means for making colored or white glass tubes or rods. PATENT-TREUHAND-GES. FÜR ELEK. GLÜHLAMPEN M. B. H. Ger. 548,443, Nov. 29, 1928. (*C.A.*)

Means for making flat articles from quartz and like difficultly fusible materials. FRITZ WINKLER (I. G. Farbenind. A.-G.) Ger. 549,083, Nov. 30, 1929. (*C.A.*)

Means for removing excess adhesive in the manufacture of safety glass. HANS KINON. Ger. 549,476, Oct. 25, 1930. (*C.A.*)

Etching glass for electric lamps. TOKUMATU TANAKA (Asahi Denki K. K.). Japan. 92,019, July 4, 1931. A mixture of NH_4F 20 g., oxalic acid 30 g., KOH 28 g., H_2SO_4 8 g., and H_2O 200 g. is used as the etching agent. It is noncorrosive to skin and the action on the glass is completed within 2 to 3 min. (*C.A.*)

Structural Clay Products

Method of brick construction which insures water-tight walls. R. H. MINTON. *Bull. Amer. Ceram. Soc.*, **11** [8], 215–18 (1932).

Suggestions for firing practice with natural gas. H. C. KENYON. *Brick Clay Rec.*, **81** [2], 56–58 (1932).—A type of fire box with the excess air opening 9 in. below the burner has several advantages over the type where the excess air opening is above the burners. In watersmoking the burner, being above the air inlet, creates a vacuum drawing the air into the fire box, and as it passes through the flame it picks up heat more readily. In windy weather the flame from the burners will not flash out so readily through the opening and endanger employees. Brick which fall into the fire box can be removed quite easily. Some ideas in regard to firing glazed ware are discussed. Illustrated. See also *Ceram. Abs.*, **11** [8], 465 (1932). E.J.V.

De-airing system for sewer-pipe presses. HOWARD S. LEWIS. *Brick Clay Rec.*, **81** [1], 14–15 (1932).—A report of a study made to improve the quality of pipe by use of a vacuum device is presented. Illustrated. E.J.V.

Apparatus for the determination of air in plastic clay bodies. H. SPURRIER. *Brick Clay Rec.*, **80** [5], 255–56 (1932); for abstract see *Ceram. Abs.*, **11** [8], 463 (1932). E.J.V.

Color range of common brick. J. W. MCBURNEY. *Jour. Clay Prod. Inst. Amer.*, **1** [2], 31–40 (1932).—This paper presents the color descriptions of the brick produced by the different districts of the U. S. using Ridgway's system of color nomenclature. A total of 182 color names was used but 152 of these are hues, tints, and shades more or less mixed with gray of the spectral range red to yellow and 99% of the brick specimens showing predominantly a single color fall within the same range. Detailed diagrams and tables are given. E.C.C.

Moisture penetration in exterior walls. H. A. GRAY. *Jour. Clay Prod. Inst. Amer.*, **1** [2], 1–25 (1932).—The factors involved in good wall construction from the standpoint of weather resistance are discussed. E.C.C.

Measurement of sound transmission through hollow-clay tile and cinder block. F. E. EMERY. *Jour. Clay Prod. Inst. Amer.*, **1** [2], 26–30 (1932).—Results of a study of the transmission of sound through various walls indicate that there is practically no difference in the sound insulation value of panels built of cinder block and hollow-clay

tile of the same weight. To resist noise of high intensity, walls of homogeneous materials must have considerable mass or else be built in layers like a double wall. It was found that a 4-in. hollow-clay tile partition with the lath and plaster furred out $^3/_4$ in. on each side had more resistance to the transmission of sound than an 8-in. solid wall, and weighed only about $^1/_2$ as much. The standard 4-in. hollow-clay tile partition with plaster applied directly to the tile has sufficient sound resistance for ordinary commercial buildings. Acoustical plaster has much the same efficiency in absorbing sound whether used on hollow tile or cinder block. E.C.C.

Relation of color to size of particles. ANON. *Brit. Clayworker*, **41** [482], 111 (1932).—A synopsis of an article by Zimmermann of Gouda which appeared in *Deutsche Ziegel-Zeitung* is presented. The investigation consisted of mixing particles of marl or chalk of various sizes with clay and firing the mixture to determine the effect on the color of the ware. With coarse particles of chalk and marl, the ware cracked and some were "blown," but those with finer particles were well fired, had a good ring, and showed no signs of cracking. The difference in the color of the fired ware containing 20% of chalk was not great, but when fired under reducing conditions, those containing chalk were a better yellow. Cracked ware was less evident when fired under reducing conditions than when fired under oxidizing conditions. R.A.H.

Increased working qualities of shales by addition of acids. A. F. GREAVES-WALKER AND W. C. BANGS. *Brick Clay Rec.*, **81** [1], 18–19 (1932).—Work done to improve the working qualities and dry strength of Triassic, Cambrian, and Pre-Cambrian shales of North Carolina by addition of acid-water solutions containing hydrochloric and sulphuric acids is reported. Addition of solutions containing 1% of acid produced considerable improvement in the clays, and sulphuric acid was found to be more effective than hydrochloric acid. E.J.V.

Testing the crushing strength of common brick. H. BURCHARTZ. *Tonind.-Ztg.*, **56** [46], 583–84; [48], 613–14; [50], 635–37 (1932).—Standard specifications for testing the crushing strength of common brick prescribe that the brick be cut in halves and cemented together. In comparison, the strength for cubes cut from the brick was found to be greater. The strength of the cemented samples varied considerably according to the cement used. The standard specifications give no reliable data of the strength of a brick. W.M.C.

Preventing scum on brick by use of barium bicarbonate. RALPH P. BROWN. *Brick Clay Rec.*, **81** [1], 16–17 (1932).—The Belden Brick Co. solved the problems of neutralizing soluble salts in clay by the use of barium bicarbonate, produced by passing scrubbed kiln flue gases through tanks of barium carbonate solution. The efficiency of the treatment is discussed. Illustrated. E.J.V.

Prevention of scum. ANON. *Brit. Clayworker*, **41** [483], 126 (1932).—The best method consists in mixing the finely pulverized carbonate with water and then adding to the clay, the water being sufficient to bring the clay to a plastic mass. R.A.H.

Resistance of brick to frost with regard to their porosity and strength. HANS HIRSCH. *Deut. Ziegel-Ztg.*, No. 10, p. 102 (1932); *Rev. mat. constr. trav. pub.*, No. 273, pp. 110–11*B* (1932); for abstract see *Ceram. Abs.*, **11** [6], 367 (1932). M.V.K.

Laminations in common brick. ANON. *Tonind.-Ztg.*, **56** [47], 598–99 (1932).—The formation and elimination of laminations are discussed. Illustrated. W.M.C.

Making large-sized brick by hand molding. ANON. *Tonind.-Ztg.*, **56** [55], 699–700 (1932). W.M.C.

Manufacture of light-weight brick from diatomaceous earth in the Ural district of Russia. SCHWIERING. *Tonind.-Ztg.*, **56** [48], 609–10 (1932).—The new plant for manufacturing light-weight brick near Swerdlowsk, Russia, is described. Large deposits of diatomaceous earth found there are used. W.M.C.

Methods by which a small plant can produce brick at the same cost as its large competitors. I. DANIEL SEUX. *Rev. mat. constr. trav. pub.*, No. 273, pp. 106–107*B* (1932).—Practical suggestions are given for rearranging the continuous kiln to obtain cheap brick of high quality. M.V.K.

New compound developed for jointing sewer pipe. NORMAN W. KELCH. *Brick Clay Rec.*, **81** [1], 24 (1932).—C.P.I.-201, a grayish green sulphur-silica compound to which a small percentage of inert materials has been added to insure the product against shrinkage, has been developed by the Clay Products Institute of California. Details of its use are given. E.J.V.

Mortar for clay products masonry. C. E. PROUDLY. *Jour. Clay Prod. Inst. Amer.*, **1** [2], 41–62 (1932).—Various mortars for brickwork are discussed. E.C.C.

Fundamentals and economies in the clay industries. XVIII. ELLIS LOVEJOY. *Clay-Worker*, **98** [1], 14–16 (1932).—L. discusses the various types of screens, pug mills,

cutters, dies, the flow of clay, waste-cut conveyers, hoist supports, and stiff-mud machines. For Part XVII see *Ceram. Abs.*, **11** [9], 491 (1932). E.J.V.

Calculating loads on sewer pipe in wide ditches. ROBLEY WINFREY. *Brick Clay Rec.*, **81** [2], 53–54 (1932).—Results of a study made to determine why quality sewer pipe fail in some installations due to faulty design of ditches are presented. E.J.V.

Value of fundamental engineering knowledge to sewer-pipe manufacturers. GEORGE C. D. LENTH. *Brick Clay Rec.*, **81** [2], 52 (1932).—Comments are offered on the importance of the investigation on the calculation of loads of pipe in wide ditches reported by Robley Winfrey. E.J.V.

Reinforced brick masonry for residential construction. ANON. *Brick Clay Rec.*, **81** [2], 50–51 (1932).—A home was recently built in Detroit, using reinforced brick masonry construction both above and below the ground, at a cost of $40 less than for brick veneer construction. Construction details and cost data are presented. Illustrated. E.J.V.

Tile built city. C. B. PLATT. *Brick Clay Rec.*, **81** [2], 62 (1932).—Structural clay tile and roofing tile are used in great quantities in the building of Randolph Field, San Antonio, Texas. Illustrated. E.J.V.

Hard-fired brick for roads. ANON. *Tonind.-Ztg.*, **56** [52], 655–56; [54], 685–86 (1932). W.M.C.

Reinforced brick masonry bridge. ANON. *Clay-Worker*, **98** [1], 24–25 (1932).—A bridge erected by the Arkansas State Highway Commission is described in detail. Illustrated. E.J.V.

Making brick in colonial Virginia. S. C. MCINTIRE. *Ceram. Age*, **18** [2], 102–103 (1931). R.G.M.

PATENTS

Method of salt-glazing brick, etc. J. B. WHITACRE (Whitacre-Greer Fireproofing Co.). U. S. 1,867,294, July 12, 1932.

Building brick. J. D. DAVIES. U. S. 1,870,102, Aug. 2, 1932. In a building construction, a veneer wall is formed of standard brick and two sets of tying corner brick.

Refractories

Joint Committee on Refractories. ANON. *Bull. Amer. Ceram. Soc.*, **11** [8], 219 (1932).

Refractory materials. IV. ALEXANDER H. HAYES. *Blast Fur. Steel Plant*, **20** [7], 611 (1932).—The effect of slags on refractories is discussed. Resistance to penetration of the slag, viscosity of the slag, a dense structure of the brick, and the formation of a glaze on the surface of the brick as the result of heat treatment are factors which have a strong influence on slag action on brick. **V.** *Ibid.*, **20** [8], 675–76 (1932).—The effect of oxides of lead, tin, zinc, sodium, and potassium, when heated on the strength of fire brick is discussed. The thermal conductivity of a brick affects the fuel consumption. Electrical conductivity of brick is important only in the case of electric furnaces. The expansion properties of brick, both positive and negative expansion, and their effects on the furnace walls and structure are briefly taken up. The resistance of brick to sudden changes of temperature is important. A frequent cause of deterioration is spalling or flaking off from the surface. Stress set up by temperature gradients in the brick is one of the causes. For Part III see *Ceram. Abs.*, **11** [8], 456 (1932). E.J.V.

Permeability of refractories. G. BATTA AND LÉON SCHERPERS. *Chim. & ind.* [Special No.], pp. 496–503 (March, 1932); for abstract see *Ceram. Abs.*, **11** [7], 414 (1932). (*C.A.*)

Expansion behavior of ordinary and "black" Dinas brick during heating. P. P. BUDNIKOFF AND W. MÜLLER. *Domex*, No. 10–11, pp. 24–28 (1931); for abstract see *Ceram. Abs.*, **11** [9], 492 (1932). (*C.A.*)

Notes on the structure of refractories. II. S. M. PHELPS. *Blast Fur. Steel Plant*, **20** [7], 612 (1932).—A discussion of the effect produced by severe heat treatment, using several differently graded brick as examples, is given, pointing out the importance of the proper size gradation of aggregates. Illustrated. For Part I see *Ceram. Abs.*, **11** [9], 492 (1932). E.J.V.

Effect of physical structure in refractories. THOMAS S. CURTIS. *Fuels & Fur.*, **10** [4], 269–72 (1932).—S. discusses the importance of proper physical structure in a re-

fractory, relation of physical structure to properties of a refractory, and service performance to be expected depending on a particular physical structure. E.J.V.

Refractories for industrial furnaces. I. F. H. NORTON. *Fuels & Fur.*, **10** [6], 383–92 (1932).—N. discusses the following types of refractories used in the construction of industrial furnaces from the standpoint of composition, manufacture, and physical characteristics: fireclay, kaolin, high-alumina, silica, magnesite, chrome, and special refractories such as zirconia, magnesium spinel, silicon carbide, fused alumina, etc. The important characteristics of the various types of refractories are summarized in tabular form. **II. Classification of industrial furnaces.** *Ibid.*, **10** [7], 443–52 (1932).—The classification of furnaces may be made according to the fuel used, the size, the maximum temperature required, continuous and intermittent, according to the type of slag occurring in the process, and according to the utilization of the heat produced. The last classification would include furnaces (1) which produce a heated product, (2) used to alter the physical structure of a material, (3) used for melting, (4) required to produce a chemical reaction (a combination of the chemical reaction and melting furnace), and (5) for utilizing the heat produced for power or to supply heat to some external unit such as a drier. Data on a large number of typical furnaces in regard to the types and amounts of refractories used, as well as their life, are presented in concise tabular form. Illustrated. E.J.V.

Sintered corundum, a ceramic material of high quality. ANON. *Sprechsaal*, **65** [28], 526 (1932).—A new ceramic material has been produced by Siemens and Galske. When pure pulverized aluminum oxide is fired to about 1800°C, an exceptionally hard crystalline material, the vitrified corundum, is obtained. Sintered corundum is especially suited for the electrotechnique because of its exceptional insulating capacity at different temperatures, high thermal strength, and thermal conductivity. It is also insensitive to sudden temperature fluctuations, has a great hardness (9), and a considerable mechanical and chemical resistance. It is an ideal material for chemical utensils. The preparation of sintered corundum and its shaping requires great care. The chemically pure alumina, without any impurities, is finely ground. Because alumina forms a positive suspensoid, an acid solution is added when preparing a paste. The shaping is made by pressing or casting. Firing is made in an electric or gas kiln. The fired body shows a dense, granite-like structure. This material is resistant to boiling with caustic soda solution, melts of sodium oxide, and carbonate, metals, glass, and slag. It is stable to hydrofluoric acid and its salts because of lack of silicic acid. Sintered corundum was shown to be gas tight at 1720°; measurements showed that its electrical resistance exceeds that of quartz glass. See also *Ceram. Abs.*, **11** [9], 494 (1932) and following abstract. M.V.K.

Sintered corundum, a new ceramic material of pure alumina. H. KOHL. *Z. angew. Chem.*, **45** [19], 334 (1932); for abstract see *Ceram. Abs.*, **11** [6], 369; [9], 504 (1932). L.T.B.

Refractory brick for lime kilns. ANON. *Rev. mat. constr. trav. pub.*, No. 273, pp. 229–30 (1932).—Magnesite and dolomite brick are highly sensible to sudden temperature changes and are not suitable for lime kilns. Silica brick when not too highly refractory are satisfactory. Brick with a high alumina content are especially good for rotary kilns. The best mixture is that having 71.8% alumina and 28.2% silica; these brick should undergo an intensive firing, however, to assure the formation of mullite. The brick should be of a moderately fine structure and uniform. Brick pressed too strongly tend to scale when undergoing sudden temperature changes. M.V.K.

Thermal decomposition of alunite. S. C. OGBURN, JR., AND H. B. STERE. *Ind. Eng. Chem.*, **24** [3], 288–90 (1932).—The progressive stages of decomposition of Utah alunite, effected by heating the material at constant temperatures and over a temperature range from 100 to 850°C, have been observed. Combined water is liberated at 460°C and complete decomposition of the aluminum sulphate to form alumina results at 800°C. Potassium sulphate is not decomposed by heating at this temperature and has been leached from the calcined material and recovered as 99.26% pure potassium sulphate. The residue after leaching consists mainly of aluminum oxide containing small amounts of silica, iron oxide, and magnesia. R.G.M.

A comparison of the rates of flow of water and of air through refractory materials. F. H. CLEWS, E. O. MILLS, AND A. T. GREEN. Inst. Gas Engrs., 22nd Rept. Refrac. Materials Joint Sub-Committee, *Copyright Communication*, No. 39, pp. 23–25 (1931); Brit. Refrac. Research Assn., *Bull.*, **25**, 48–54 (1931).—Determinations were made of (1) the time taken for water to penetrate a brick specimen 3 in. in thickness (time of penetration), and (2) the rate of flow of water through the specimen before and after saturation (permeability). When the different brick are placed in order of increasing pene-

trability (decreasing time of penetration) they are also arranged in order of increasing permeability to water. This order is very nearly the same as that of increasing permeability to air. (*C.A.*)

Impervious crucibles of magnesium oxide. P. S. ROLLER AND DAVID RITTENBERG. *Ind. Eng. Chem.*, **24** [4], 436–40 (1932).—The authors describe the preparation of refractory crucibles of magnesium oxide that are recrystallized to translucency and are impervious to air under pressure at room temperature. The crucibles are formed by pressing the moistened refractory powder in two steps in such a manner that the base is welded onto the walls, thus obtaining uniform density and strength. They are fired in a high-frequency induction furnace with graphite inductor at a temperature of about 2600°C. Significant variables are (1) the relative pressure in forming the base and walls, (2) the fineness distribution of the refractory powder, and (3) the duration of firing above 1800°C. Because of their dense structure, these crucibles are much more resistant to attack by slags than are porous crucibles. R.G.M.

Carboniferous crucibles. ANON. *Brit. Clayworker*, **41** [483], 141 (1932).—The addition of graphite to fireclay crucible mixtures makes the resulting crucibles less sensitive to sudden temperature changes and increases their thermal conductivity. The strength of the heated crucible is also increased. Great improvements have been effected by making crucibles of a material in which the carbon is chemically combined. The most suitable compound for this purpose is silicon carbide. Crucibles of great strength and rapid heating power without sensitiveness to fracturing during rapid temperature changes can now be made. R.A.H.

Glassmelting pots made from "Grossalmerode" clay by producers in Germany. ANON. *Amer. Glass Rev.*, **51** [26], 10 (1932). E.P.R.

Manufacture of refractory materials for steel mills. ANON. *Tonind.-Ztg.*, **56** [49], 623–24 (1932). W.M.C.

Al_2O_3-rich refractory materials. R. RIEKE. *Z. angew. Chem.*, **45** [19], 334 (1932); for abstract see *Ceram. Abs.*, **11** [9], 493 (1932). L.T.B.

Developments in unfired magnesite brick. A. E. FITZGERALD. *Blast Fur. Steel Plant*, **20** [8], 658–60 (1932); see also *Ceram. Abs.*, **11** [7], 416 (1932). E.J.V.

Heat-insulating brick. T. H. BLAKELY AND J. W. COBB. *Blast Fur. Steel Plant*, **20** [5], 452 (1932); see also *Ceram. Abs.*, **11** [9], 494 (1932). E.J.V.

Properties of quartz. B. BRABEC. *Chim. & ind.* [Special No.], p. 483 (March, 1932); for abstract see *Ceram. Abs.*, **10** [7], 504 (1931). (*C.A.*)

Resistance against thermal shock of brick arches for locomotives. A. PUSCH. *Tonind.-Ztg.*, **56** [47], 600–601 (1932).—The thermal shock test is described. The new standard specifications are given for brick to be used in locomotive firings. W.M.C.

Expansion of Chassov-Yar fire brick at high temperatures. P. P. BUDNIKOFF AND W. MÜLLER. *Domez*, No. 12, pp. 11–14 (1931); for abstract see *Ceram. Abs.*, **11** [9], 493 (1932). (*C.A.*)

Preparation and shaping of refractory materials in Germany. I. OTTO PHILIPP. *Feuerfest*, **8** [6], 81–89 (1932).—P. describes in detail (1) crushing apparatus, (2) sifting contrivances and installations, and (3) preparation of plastic mixes, nonplastic mixes, grog cast batches, silica mixes, and contrivances used for them. Under shaping he discusses (*a*) plastic ware, (*b*) cast ware, and (*c*) nonplastic and slightly plastic ware. M.V.K.

State of standardization of refractory materials. H. KALPERS. *Glashütte*, **62** [21], 360–62 (1932).—K. describes the reasons which led to the first attempts to standardize refractories and the results obtained. There are at present 8 standard specifications: (1) Definition and general specifications: materials having a melting point not lower than 1580° are considered to be refractory. The difference between natural and artificial refractory materials is specified. To the class of artificial refractories belong the following products: (*a*) Silica products obtained from free mineral, silica as the chief constituent and a bonding agent (lime). (*b*) Products containing alumina: clay brick obtained from unfired clay; grog products, a mixture of fired and unfired refractory clays only; quartz-grog products produced by using the 2 groups given above and an addition of free mineral silica; and alumina products obtained from free alumina (to this group belong bauxite, diaspore, and corundum). (*c*) Magnesite products obtained from raw materials containing magnesium oxide chiefly. (*d*) Other refractory products produced from dolomite, carbon, silicon carbide, chromite, sillimanite, and zircon. Quartz slate and luting sand are natural refractories obtained through mechanical working from natural raw materials. (2) Chemical analysis gives specifications for the preparation of samples and the definite constituents only. (3) Refractoriness is determined in electric resistance kilns with Seger cones. (4) Soften-

ing under load at high temperature. (5) Requirements for specific gravity and determination of volume and porosity. (6) Determination of the resistance to pressure at room temperature. (7) Data on the dimensions of refractories. (8) Quality specifications and deviations in the chemical analysis; the limits for silica in silica brick are -1% SiO_2; for alumina in grog brick, -1% Al_2O_3; and for iron oxide, $+0.3\%$ Fe_2O_3. Standard specifications dealing with after-shrinkage and increase in size, resistance to sudden temperature changes, stability to the attack of solid and liquid materials at high temperatures (stability to slagging), and methods of testing are not yet approved. M.V.K.

Standard testing methods for refractory materials in Germany and abroad. L. LITINSKY. *Glastech. Ber.*, **10** [4], 295 (1932); for abstract see *Ceram. Abs.*, **9** [7], 538 (1930). M.V.K.

Refractories research. ANON. *Times Eng. Supp.* [Ann. Rev.], **29**, 16 pp. (Jan. 30, 1932); *Refrac. Jour.*, **8** [2], 76 (1932).—Two recent formulas are discussed: (1) Braunbeck's, that the melting point of a substance varies as the lattice distance in the crystal and also inversely as the fourth root of the compressibility; and (2) Werner's, that the logarithm of electric conductivity of refractory materials varies as the absolute temperature. H.H.S.

Economic problems confronting the refractories industry. C. E. BALES. *Brick Clay Rec.*, **81** [1], 26–27 (1932); *Refrac. Jour.*, **8** [6], 207–208 (1932).—Problems confronting the refractories industry include (1) low demand for products, (2) better brick giving longer life and thus decreasing consumption, (3) elimination of clay refractories in some industries, (4) increased losses due to rigid inspection, and (5) uncontrolled competition. E.J.V.

Plants of the Climax Fire Brick Co. CHARLES LONGENECKER. *Blast Fur. Steel Plant*, **20** [7], 596–97 (1932).—Historical data and a general discussion of the products of the company are given. Illustrated. E.J.V.

Aluminous refractory materials. ANON. *Refrac. Jour.*, **8** [7], 266–68 (1932).—The mining future of the aluminous refractory materials, cyanite, sillimanite, and corundum, in northern India seems to be dependent upon two factors, *viz.*, the favorable outlook with which the users accept the materials, and the producer's ability to place them sufficiently cheaply on the market. E.P.R.

Refractory institute in Russia. ANON. *Feuerfest*, **8** [6], 99 (1932).—The people's commissaries for heavy industry decided to open an institute for studying refractory and acid-stable materials in Moscow. The institute will have branches in Leningrad, Charkov, and the Urals. M.V.K.

BULLETINS

Refractoriness under load. ANON. *Refrac. Bull.*, March, 1932; abstracted in *Refrac. Jour.*, **8** [6], 240 (1932).—The resistance shown by fire brick to load at high temperatures depends on many factors. With fireclay materials there is generally a variable and extended range of temperature between the beginning of subsidence and the point of complete collapse. Usually the temperature of initial softening falls rapidly with increase in flux content. A reducing furnace atmosphere has a pronounced effect in rapidly reducing the viscosity of the bond. Deformation is therefore hastened. With silica refractories the underload resistance largely depends on the degree of the conversion of the original to cristobalite and tridymite. Thorough firing ensures maximum conversion. For high resistance it is necessary to produce a brick which has a large number of interlocking tridymite crystals. E.P.R.

Refractories and their testing. ANON. *Refrac. Bull.*, No. 4; abstracted in *Refrac. Jour.*, **8** [5], 190 (1932); for abstract see *Ceram. Abs.*, **11** [8], 457 (1932). E.P.R.

Silica volume changes. ANON. *Refrac. Bull.*, No. 5; abstracted in *Refrac. Jour.*, **8** [6], 234 (1932).—One of the features of silica is its ability to exist in a number of different forms. The dangerous time in heating or cooling 95% silica brick is at extremely low temperatures. Providing care is taken below dull redness, considerable fluctuations in temperature can be permitted without risk of spalling. E.P.R.

Book Review

Magnesite and Its Workabilities. Vol. 28 of the Technical Progress Reports. R. BANCO. Preface by C. A. Goslich. 70 pp. and 21 illustrations. Price 5M, bound 5.80M. Published by Theodore Steinkopf, Dresden, 1932. Based upon practical experience of many years and knowledge of prevailing publications, B. gives a brief but exhaustive presentation dealing with the manufacturing process of magnesite, its properties, and its behavior during manufacturing, especially if formed. The following sub-

jects are discussed: (1) raw magnesite, (2) caustic burned magnesite, (3) sintered magnesite, (4) magnesite brick, and (5) microstructure of magnesite brick. A bibliography is included.

PATENTS

Alumina. J. C. SEAILLES. U. S. 1,856,194, May 3, 1932.

Manufacture of aluminum chloride. A. McD. McAFEE (Gulf Refining Co.). U. S. 1,867,672, July 19, 1932.

Furnace wall. A. L. KEELER. U. S. 1,868,171, July 19, 1932. A. E. NASH (Alcorn Combustion Co.). U. S. 1,870,783, Aug. 9, 1932.

Furnace construction. R. L. LEVENTRY (Republic Iron and Steel Co.). U. S. 1,868,172, July 19, 1932. R. D. FOLTZ (M. H. Detrick Co.). U. S. 1,868,352, July 19, 1932, and 1,870,721, Aug. 9, 1932. L. H. HOSBEIN (M. H. Detrick Co.). U. S. 1,870,568, Aug. 9, 1932. LOUIS ELLMAN (M. H. Detrick Co.). U. S. 1,870,615, Aug. 9, 1932.

Method of applying protective refractory glaze to refractory bodies containing silicon carbide. S. F. WALTON (Exolon Co.). U. S. 1,868,451, July 19, 1932. The method of protecting clay bonded silicon carbide bodies against corrosion consists in fusing onto the body as an exterior integral coating, a refractory glaze composed of a mixture of finely divided prefused aluminum silicate and raw aluminum silicate of substantially the same composition as the clay bond of the silicon carbide body whereby the union of the clay coating with the body is unaffected by unequal expansions of the coating and body.

Process of recovering alumina from siliceous materials containing it. W. M. GUERTLER (Electric Smelting & Aluminum Co.). U. S. 1,868,499, July 26, 1932.

Method of making composite refractory articles. G. S. FULCHER (Corning Glass Works). U. S. 1,868,699, July 26, 1932. The method of making refractory articles for use in contact with molten glass includes placing an unfired refractory backing member in a mold and introducing into the mold molten aluminum silicate which, due to its own heat, will fuse with the backing member.

Refractory lining for melting pots. G. R. BROPHY AND GUISEPPE SCORZONI (General Electric Co.). U. S. 1,870,034, Aug. 2, 1932. A method of coating a metal receptacle comprises applying to the inner surface of the receptacle a mixture consisting largely of calcium hydroxide but containing water, an organic binder, and an inorganic binder, drying the coating, and then baking the coating at a temperature varying from 500 to 700°C.

Production of aluminium fluoride-alkali fluoride double compounds. H. A. GILL (Saline Ludwigshalle). Brit. 361,031, Aug. 9, 1930. (*B.C.A.*)

Extraction and refinement of alumina. VEREINIGTE ALUMINIUM-WERKE AKT.-GES. AND H. GINSBERG. Brit. 375,476, July 6, 1932.

Method of making bonded articles containing silicon carbide. CARBORUNDUM CO., LTD. Brit. 377,090, July 27, 1932.

Refractory blocks. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Fr. 720,317, Oct. 17, 1930. Blocks for the construction of glass furnaces are made by fusing in an electric furnace pieces of CaO free from MgO and not containing more than 0.2% of Al with SiO_2 also in pieces and not containing more than 0.3% of Al, so that the bath contains CaO 56 and SiO_2 60 parts. The fused mass is molded and allowed to cool very slowly. Up to 5% of F or fluorspar in pieces may be incorporated in the mixture before fusion. (*C.A.*)

Alumina. ALTERRA AKT.-GES. Fr. 720,521 and 720,522, July 23, 1931. Al_2O_3 is obtained from clays, kaolins, etc., by calcining the substance at a temperature below 900°. Certain conditions which vary according to the nature of the material treated must be observed. These conditions are determined by experiments based on the rule that the solubility of the Al_2O_3 in H_2SO_3 increases for a given temperature with the duration of heating and, for a given duration, with the temperature, a maximum being obtained in each case, after which the solubility decreases. The material is then treated with a solution of SO_2. Silicic acid is eliminated from mixtures of silicic acid hydrate and $Al(OH)_3$ by dissolving the mixture in dilute SO_2 solution without artificial drying and heating the solution at a progressively increasing temperature, without escape of SO_2, until the solution becomes turbid and the silicic acid coagulated. The precipitate is separated when cold. (*C.A.*)

Aluminum. GUSTAV MÜNCH (I. G. Farbenind. A.-G.). Ger. 485,431, Jan. 22, 1927. In the manufacture of Al from Al_2O_3 by electrolysis in a fused bath, use is made of calcined Al_2O_3 which has been ground under pressure to increase its apparent density. See following patent. (*C.A.*)

Alumina. HEINRICH SPECKETER, FRITZ ROSSTEUTSCHER AND CONRAD ROSEN-

BERGER (I. G. Farbenind. A.-G.). Ger. 547,695, Aug. 22, 1926. Clay and other crude aluminoferrous materials are treated with H_2SO_4, and the dissolved Al and Fe sulphates separated from the insoluble residue. This solution is treated with an amount of alkali chloride equivalent to the SO_3 content of the solution and heated to 700°. HCl is evolved without addition of steam. The product is mixed with C and reduced at about 1000° to give aluminate, sulphide, and soda. The Al_2O_3 is separated from the washings of the fused mass by precipitation. The alkali products are obtained by evaporation. (*C.A.*)

Method for preparing dense and solid objects and vessels from zirconium oxide and other high refractory oxides. DEUTSCHE GASGLÜHLICHT-AUER GES. Ger. 543,772, June 22, 1927; *Feuerfest*, **8** [6], 92 (1932).—A small quantity of oxides of magnesium or aluminum and some salt solution are added to the sintered oxides to make a plastic mass which can be shaped, or to a slip which can be cast. The quantity of salt solution is small and when using 5% of magnesium or aluminum oxides it amounts to about 10% of the oxides added. A part of the electrolyte additions may be replaced by adding free acid. The objects produced in this special way show an increased strength in their wet or dry state, and show a very dense and solid body after firing. Magnesium oxide considerably improves the plasticity and capability of casting of the mass when adding an electrolyte. M.V.K.

Porous bodies from glass, quartz, etc. FRITZ WINKLER (I. G. Farbenindustrie A.-G.). Ger. 545,682, Feb. 7, 1930. Apparatus and a method of producing a porous product by surface-sintering granular glass, quartz, etc., are described. (*C.A.*)

Chamotte. SCHEIDHAUER & GIESSING A.-G. Ger. 546,582, March 16, 1926. Chamotte is produced by intimately mixing kaolin with electrolytes to form a slip which is then mechanically worked up and fired. (*C.A.*)

Purifying aluminous materials. CONWAY VON GIRSEWALD AND PHILIPP BABEL (Metallges. A.-G.). Ger. 547,107, Oct. 15, 1929. The materials are calcined at a temperature between 500 and 900°, preferably between 600 and 800°, and are then partially chlorinated in a known manner to remove Fe, Ti, etc., as volatilized chlorides. Details and examples are given. (*C.A.*)

Refractory mortar for silica brick. C. OTTO & CO. G.M.B.H. Ger. 549,262, Nov. 21, 1928. A material rich in SiO_2, *e.g.*, a mixture of quartzite sand and finely ground SiO_2, is mixed with 2 to 4% of CaO. (*C.A.*)

Terra Cotta

Dips and engobes. ANON. *Brit. Clayworker*, **41** [483], 133 (1932).—Most dips and engobes are composed of several substances, the most important of which are clay, feldspar or other flux, and some form of free silica to reduce the shrinkage. The article discusses some precautions relative to the materials used, shrinkage of the dips, and condition of the ware being dipped. R.A.H.

Influence of firing temperature on the water permeability and resistance to freezing of roofing tile. ANON. *Tonind.-Ztg.*, **56** [47], 596–97 (1932). W.M.C.

Stoneware caissons. F. SCHRADER. *Tonind.-Ztg.*, **56** [51], 648–49 (1932).—This paper gives details as to the best forms of caissons. Illustrated. W.M.C.

White glazed clay for food plants. ANON. *Ceram. Age*, **18** [5], 256 (1931). R.G.M.

Use of glazed units. ANON. *Brick Clay Rec.*, **81** [2], 48 (1932).—The use of colored glazed clay products in the construction of a super-service station of the Goodyear Tire & Rubber Co. in Cleveland is cited. Illustrated. E.J.V.

Use of glazed tile in Spain. ANON. *Pottery Gaz.*, **57** [662], 981 (1932).—The fountains recently erected at Tarifa and Algeciras, Spain, are effective examples of the use of glazed tile. Illustrated. E.J.V.

Development of terra cotta. S. J. MCDOWELL. *Fuels & Fur.*, **9** [11], 1303–1304 (1931).—A brief description of the material "terra cotta" and its early history and development are given. Illustrated. E.J.V.

The use of fired clay. HENRI GILARDONI. *Brit. Clayworker*, **41** [483], 124–26 (1932).—The use of fired clay for special constructions and for public monuments is universal and goes back to remote antiquity. Examples taken from many countries are given. The advantages of brick and terra cotta are discussed. R.A.H.

PATENTS

Flowerpot. L. D. MENNELL AND WHEELER LAFFERTY. U. S. 1,869,606, Aug. 2, 1932.

Ceramic products from alkali-free magnesium silicates. RUDOLF POLLAK AND WILHELM WEBER. Ger. 544,681, Sept. 2, 1926. Crude alkali-free Mg silicate minerals such as serpentine, chlorite, speckstone, etc., are sintered with prepared $MgSiO_3$ and a 10% addition of Al_2O_3. The product is ground and worked up to a ceramic clay which gives objects of considerable chemical resistance and of mechanical tenacity. (*C.A.*)

Glazing stoneware. DEUTSCHE TON & STEINZEUGWERKE A.-G. Ger. 548,253, Jan. 1, 1930. The molded article is superficially treated prior to firing with a solution or suspension of a compound of Mg or an alkaline earth metal, and is then salt-glazed in a known manner. The glazed surface has marked water-repelling properties. (*C.A.*)

White Wares

Review possibilities of enamel frit in whiteware bodies. DAVID H. ROWLAND, ARTHUR S. WATTS, PAUL E. COX, AND A. F. GREAVES-WALKER. *Ceram. Ind.*, **19** [2], 67–68 (1932).—The authors give opinions on the use of auxiliary fluxes in whiteware bodies, including electrical porcelain, tableware, etc. W.W.M.

Insulators for the transmission of electricity at high voltages. ANON. *Mech. World*, **91** [2372], 585 (1932).—The recent erection of the grid transmission system for the distribution of electric current over the country at 132,000 volts has necessitated a study of the most efficient design for the insulators which suspend the high-voltage lines from the supporting towers. These insulators are made of porcelain, and a number of them, varying from one to ten, are strung together to provide the necessary insulation, depending on the voltage of the lines. Tests of such insulators are made in the million-volt electrical plant at the National Physical Laboratory. The shape of the insulators is of considerable importance and should be such as to minimize their contamination by the smoke, etc. The most satisfactory results under bad conditions were given by insulators with a vertical or steep outer surface, which retained good insulating properties under all conditions. E.P.R.

Manufacture of porcelain by the casting process. A. H. FESSLER. *Fuels & Fur.*, **10** [4], 291–93 (1932).—The casting process is explained and its advantages are pointed out. The function of ball clays, china clays, water content, and electrolytes in casting slips is taken up. The three methods of casting, (*a*) centrifugal casting, (*b*) pressure casting, and (*c*) mold vibration, are described in detail. E.J.V.

PATENTS

Compensating strut type insulator. A. O. AUSTIN (Ohio Brass Co.). U. S. 1,868,479, July 26, 1932.

Pyrometer tube. J. A. JEFFERY AND F. H. RIDDLE (Champion Porcelain Co.). U. S. 1,869,151, July 26, 1932.

Insulator. C. L. STROUP. U. S. 1,869,397, Aug. 2, 1932.

Combination closet bowl and tank structure. C. H. ZWERMANN. U. S. 1,869,401, Aug. 2, 1932.

Pottery drying boards. J. CADMAN & CO., LTD., AND C. F. PROCTOR. Brit. 375,378, July 6, 1932.

Water closets. O. LUNDBERG. Brit. 375,382, July 6, 1932.

Pedestals for lavatory basins, etc. P. G. DONALD. Brit. 376,051, July 13, 1932.

Baths, sinks, wash and lavatory basins, etc. R. H. LANCASTER AND A. J. FOSTER. Brit. 376,981, July 27, 1932.

Equipment and Apparatus

High-temperature controls: photoelectric tube pyrometry. L. B. KOLLER. *Ind. Eng. Chem.*, **23** [12], 1379–81 (1931).—K. describes developmental work done in a laboratory on a photoelectric tube apparatus, by means of which it is possible to control the temperature of industrial furnaces. This method can be applied to temperatures of 1000 °C and upward. The principle involved, the circuit, and limits of accuracy of the method are described. R.G.M.

Portable pyrometer. ANON. *Glass*, **9** [4], 160 (1932).—A pocket radiation pyrometer which claims to eliminate the defects experienced with other types is discussed and illustrated. G.R.S.

High-temperature measurement. "PYROS." *Glass*, **9** [1], 8–13; [2], 52–57 (1932).—The various methods of measuring high temperatures are classified as follows: (1) direct measuring thermocouples, (2) electric-resistance pyrometers, (3) radiation type pyrometers, and (4) optical type pyrometers. G.R.S.

The pachimeter as an instrument for testing materials, with special reference to clays, soils, and flours. G. W. SCOTT BLAIR AND R. K. SCHOFIELD. *Jour. Rheol.*, **3** [3], 318–25 (1932).—The pachimeter measures the stress required to start plastic flow in a deformable material. It is easily and cheaply constructed, is rapid in its working, and normally should necessitate very little pretreatment for the sample to be tested. Very small quantities of the sample can be used. G.R.S.

Graphical determination of the apparent porosity of ceramic products. A. ALISON. *Glass*, **9** [4], 158–59 (1932).—The construction of a nomograph for the determination of the porosity of ceramic products is described and its use explained. G.R.S.

Process control with the phototube. H. OLKIN. *Factory & Ind. Management*, **83** [7], 268 (1932).—For continuously measuring the moisture content of paper a device has been perfected which is as follows: A rayon ribbon stretched along the mouth of a metal pocket is situated above and close to the web of paper but not touching it. The web travels by the ribbon at high speed and draws a rush of air along with it. The humidity of this air varies with the wetness of the paper. As the air circulates through the metal box around the ribbon, the rayon gets longer or shorter depending on the moisture content of the air. The changes in length amounting only to thousandths of an inch are indicated by a radio measuring device and read on a meter which exaggerates the dimensional changes of the ribbon. The scale is graduated directly in moisture content. E.C.C.

Tests of a balanced thermocouple and filter radiometer as a standard ultra-violet dosage intensity meter. W. W. COBLENTZ, R. STAIR, AND J. M. HOGUE. Bur. Stand. *Jour. Research*, **8** [6], 759–78 (1932). R.A.H.

Application of photoelectric cells sensitive in the infra-red to stellar photometry. JOHN S. HALL. *Proc. Nat. Acad. Sci.*, **18** [5], 365–67 (1932). J.L.G.

Optical method for measuring temperature distribution and convective heat transfer. R. B. KENNARD. Bur. Stand. *Jour. Research*, **8** [6], 787–805 (1932). R.A.H.

Optical research in glass, enamel, and pottery. C. R. AMBERG. *Ceram. Ind.*, **19** [2], 61–63 (1932).—A. discusses the possibilities of the petrographic microscope and X-ray in obtaining exact scientific knowledge of ceramic products and materials. Illustrated. W.W.M.

Usual machines for preparing raw materials used in ceramics, their application and efficiency. E. HAUMEDER. *Feuerfest*, **8** [6], 99 (1932).—H. describes different types of crushing machines, rolling mills, edge mills, ball mills, tubular mills, drum mills for dry and wet grinding, elutriating devices with special regard to the working of kaolin according to the elutriating and electroösmosis methods, deferrizing apparatus, dehydrating installations such as filter-presses, sucking cell filters, clay-pugging machines, and sieving installations. M.V.K.

Modern methods in the production of porcelain grinding balls and lining blocks. R. L. CAWOOD. *Ind. Eng. Chem.*, **23** [8], 865–67 (1931).—C. describes the manufacture of balls and blocks. An automatic ball-spinning machine is described. R.G.M.

New vibrating screen. STEDMAN'S FOUNDRY & MACHINE WORKS. *Brick Clay Rec.*, **81** [2], 68 (1932).—High screening efficiency, simplicity of design, and rigidity of construction are the major features of the Quadrex screen. Illustrated. E.J.V.

Testing sieve shaker. NEWARK WIRE CLOTH CO. *Metal Cleaning & Finishing*, **4** [7], 421 (1932); for abstract see *Ceram. Abs.*, **11** [9], 498 (1932). E.J.V.

Relationship of theory and experience in industrial drying and processing. I. C. F. MAYER. *Fuels & Fur.*, **10** [1], 41–44 (1932).—A general résumé of the various types of ovens or driers used for drying purposes is presented. A theoretical knowledge of heating, ventilation, and humidity is an important factor in solving drying problems. The proper choice of fuel for the drier is stressed. Illustrated. **II.** *Ibid.*, **10** [2], 129–32 (1932).—The four general heating systems available for consideration, indirect radiator type, indirect external heater type, direct-fired burner, and direct-fired external heater type, are discussed. Oil heating, electric heat, and steam heat, as well as the different kinds of coal and coke firing methods are taken up. Illustrated. **III.** *Ibid.*, **10** [3], 199–202 (1932).—The steps leading up to and including the development of the modern panel type of industrial oven construction are discussed. Illustrated. **IV.** *Ibid.*, **10** [5], 349–52 (1932).—M. discusses the relative importance of joint losses with respect to total radiation loss of an oven. The method of practical heat loss determination, heat input formulas, and laboratory heat loss determination are given.

Illustrated. **V. Determination of oven requirements.** *Ibid.*, **10** [7], 461–64 (1932).—Another phase of industrial oven construction is discussed, *i.e.*, oven requirements when making an installation, *e.g.*, capacity, method of handling materials, space available, and accompanying processes. Illustrated. E.J.V.

Laboratory furnace for high temperatures. H. S. Booth and R. Ward. *Ind. Eng. Chem.* [Anal. Ed.], **4** [2], 199–200 (1932).—The construction of a furnace capable of maintaining a temperature constant to ±5° in the range 1000 to 1500°C is described. "Globar" elements were used. Illustrated. R.G.M.

Science and practice of drying. XVI. Anon. *Brit. Clayworker*, **41** [483], 122–23 (1932).—A description is given of the Dorst mechanized drier. It is 140 ft. long, 21 ft. high, and 7½ ft. wide and has a drying capacity of 13,000 brick per day with drying completed in 37 hr. The initial hot temperature is 176°F and the exit temperature is about 86°F. Typical calculations are given for determining the heat necessary to dry a standard size brick, and a supplementary heating furnace for use with driers is briefly described. For Part XV see *Ceram. Abs.*, **11** [9], 498 (1932). R.A.H.

Opportunities for using indicating and recording control instruments in the rock products industries. Instrumentation in the glass industry. James R. Withrow. *Rock Prod.*, **35** [14], 18–21 (1932).—W. cites the uses of indicating and recording control instruments in the glass industry, including the melting and annealing of plate glass, window glass manufacture, and the production of lamp bulbs. Instrumentation improves the quality of the product and at the same time effects an economy of production. W.W.M.

Application by means of a spraying apparatus. Math. Becker. *Emailletech. Monats-Blätter*, **8** [6], 43–44 (1932).—The use of spray machines for the application of both ground-coat and cover-coat enamels is discussed. The ease with which small articles and complicated shapes can be coated with enamel by use of spraying apparatus is pointed out. E.J.V.

Dual voltage connections for induction motors. A. C. Roe. *Maintenance Eng.*, **90** [7], 295–97 (1932).—This is the first of a series of articles which are being presented to show how the windings of 2- to 24-pole, two- and three-phase motors can be arranged for dual control. Two-phase schematic line diagrams are explained in the present article. Illustrated by diagrams. J.L.G.

Apparatus for cutting brick, etc. P. Renault. *Rev. mat. constr. trav. pub.*, No. 273, pp. 114–16*B* (1932); see also *Ceram. Abs.*, **11** [9], 498 (1932). M.V.K.

Autoclave test for glazed products. Anon. *Tonind.-Ztg.*, **56** [56], 711–12 (1932).—The application of autoclave tests as developed in the U. S. since 1928 is reviewed. W.M.C.

PATENTS

Thermostat. A. A. Dicke (Pioneer Heat Regulator Co.). U. S. 1,866,548, July 12, 1932.

Machine for finishing articles of pottery ware. J. E. Wright and G. A. Benline. U. S. 1,867,790, July 19, 1932.

Method and apparatus for manufacturing pottery ware. W. J. Miller. U. S. 1,868,425, July 19, 1932.

Brick press. F. H. Bankert (Chicago Retort and Fire Brick Co.). U. S. 1,869,995, Aug. 2, 1932.

Induction-furnace lining. N. R. Davis and G. A. Wood (Westinghouse Electric & Mfg. Co.). U. S. 1,871,159, Aug. 9, 1932.

Ramming machine for preparing solid and hollow bodies from ceramic, concrete, etc., materials. P. Richter, Richter & Nordmeier Ges., and R. H. Baumgarten. Brit. 376,355, July 20, 1932.

Kilns, Furnaces, Fuels, and Combustion

Commercial butane as a ceramic fuel. C. F. Greene. *Jour. Amer. Ceram. Soc.*, **15** [9], 495–500 (1932).

Domes for circular kilns. J. A. Fellows. *Jour. Amer. Ceram. Soc.*, **15** [9], 508–16 (1932).

A new kiln. Anon. *Tonind.-Ztg.*, **56** [49], 620–21 (1932).—This kiln is composed of a number of movable units which form a tunnel kiln. Illustrated. W.M.C.

Mechanical draft for kilns. Anon. *Brit. Clayworker*, **41** [482], 112–13 (1932). R.A.H.

Fuel feeding in annular kilns. SCHIRM. *Feuerungstechnik*, **20** [6], 90–93 (1932).—S. discusses different installations used for feeding annular kilns having electricity, compressed air, or force of gravity as motive power. M.V.K.

Continuous electric decorating kiln. ELECTRIC FURNACE CO. *Fuels & Fur.*, **10** [5], 353–55 (1932); for abstract see *Ceram. Abs.*, **11** [5], 317 (1932). E.J.V.

Electric circular decorating kiln. AJAX ELECTRIC CO., INC. *Fuels & Fur.*, **10** [1], 81–82 (1932); for abstract see *Ceram. Abs.*, **11** [3], 199 (1932). E.J.V.

New pot furnace determines softening point of clays. DENVER FIRE CLAY CO. *Gas Age-Rec.*, **70** [1], 23 (1932).—A new P.C.E. furnace recently placed on the market is described. Illustrated. E.J.V.

New continuous enameling furnace for cast iron and steel products. ELECTRIC FURNACE CO. *Fuels & Fur.*, **10** [4], 295–96 (1932).—The construction and operation of this furnace are described. Illustrated. E.J.V.

Smokeless fuel. ANON. *Mech. World*, **92** [2378], 105 (1932).—The latest development in the treatment of coal comes from Ashby-de-la-Zouche, where British Coal Distillation, Ltd., has erected a plant which converts "slack" into smokeless fuel and oil. This "slack" coal is stated to be worth only 2s to 3s per ton, and to produce a profit at present prices of 3s 9d per ton treated. This smokeless fuel is intended, presumably, to replace coal of better quality consumed in various ways. For a given heat consumption this would tend to reduce the quantity of coal produced but would improve the efficiency at which the coal is mined by making more of the total quantity of material usable. E.P.R.

Use of fuel oil for firing heavy ceramic products. I. L. A. MEKLER. *Fuels & Fur.*, **9** [3], 351–56 (1931).—The various properties of fuel oils with reference to the selection of the proper fuel oil to give best results at least cost are discussed. **II. Fuel-oil circulating lines.** *Ibid.*, **9** [4], 467–69 (1931).—The circulating system of fuel-oil delivery (series and parallel flow) as used in the heavy clay products industry is discussed. Illustrated. **III. Fuel oil circulating pumps.** *Ibid.*, **9** [6], 719–22 (1931).—The construction and operating characteristics of the various types of pumps as applied to the fuel-oil circulating system in the ceramic industry are discussed. Illustrated. E.J.V.

Better heat handling for economy in gas firing. J. B. NEALEY. *Ceram. Age*, **18** [5], 253–55 (1931); *Natural Gas*, **13**, 38, 48 (Feb., 1932).—N. presents a description of the Vulcan plant of the National Fireproofing Co. at Birmingham, Ala. R.G.M.

Data. IX. T. W. GARVE. *Clay-Worker*, **98** [1], 18–19 (1932).—Information regarding fuels includes data on the various woods and the different classes of coal, coke, and peat. Not only characteristics of each type of fuel but comparative data are presented. For Part VIII see *Ceram. Abs.*, **11** [9], 491 (1932). E.J.V.

Dust in flue gases: methods of removal. J. MAYER. *Times Eng. Supp.*, **30**, 151 (1932).—Gravity separation can be carried out only by reducing the velocity of the flue gases to about 4 ft. per sec. Other methods are bag filters, electrical precipitation, centrifugal collectors, and various washing systems. H.H.S.

Analysis of flame phenomena in combustion. K. BUNTE. *Gas Wasserfach*, **75**, 213–18 (1932); *Gas Age-Rec.*, **70** [6], 143 (1932).—Revised ignition velocity charts for the following commoner hydrocarbons and mixtures of these gases with CO are given: methane, ethylene, acetylene, propylene, pentane, hexane, cyclo-hexane, benzene, ethyl-ether, and acetone. E.J.V.

Calculating the process of combustion when burning gas mixtures. WILLI BÄHREN. *Feuerungstechnik*, **20** [6], 81–85 (1932).—B. shows how to calculate gas mixtures consisting of blast-furnace gas and coke gas and coal-dust gas, blast-furnace gas, and coke gas. M.V.K.

Common error in flue gas analysis and heat balances. W. TRINKS. *Fuels & Fur.*, **10** [6], 411–12 (1932).—The effect of hydrogen in flue gases and results of tests are presented. A calculation of the heat loss due to hydrogen in flue gases is made, and the importance of getting a complete analysis of flue gases rather than the customary oxygen, carbon dioxide, and carbon monoxide determination is pointed out. E.J.V.

Heat exchange in modern industrial practice. III. Heat transfer in stream-line flow. B. HEASTIE. *Ind. Chemist*, **8**, 172–74 (1932).—A review and correlation of theoretical and experimental work on heat transfer from walls at constant temperature to oils flowing through a tube are given. (*B.C.A.*)

Geometry of the heat equation: first paper. EDWARD KASNER. *Proc. Nat. Acad. Sci.*, **18** [6], 475–80 (1932).—A type of family of plane curves designated as heat family or family of heat curves is considered with the equations pertaining thereto. J.L.G.

Determining the most favorable design of gas burners. JOHN H. EISEMAN, ELMER R. WEAVER, AND FRANCIS A. SMITH. Bur. Stand. *Jour. Research*, **8** [6], 669–709 (1932). R.A.H.

Industrial chimneys. ANON. *Brit. Clayworker*, **41** [483], 131–32 (1932).—In spite of forced drafts, electrical heating, and condenser systems, the old-fashioned chimney stack is still built with almost as much consistency as before. Dimensions and construction details are discussed. R.A.H.

BOOKS AND BULLETIN

Fuel Testing. GODFREY W. HIMUS. *Can. Chem. Met.*, **16** [7], 43 (1932); for review see *Ceram. Abs.*, **11** [9], 501 (1932). E.J.V.

Advice on Firing Brick and Tile Kilns. J. WELTER. *Brit. Clayworker*, **41** [483], 127–30 (1932); for review see *Ceram. Abs.*, **11** [9], 500 (1932). R.A.H.

Inflammability of mixed gases: mixtures of methane, ethane, hydrogen, and nitrogen. G. W. JONES AND R. E. KENNEDY. Bur. Mines *Rept. of Invest.*, No. 3172. 12 pp. Free. The limits of inflammability of these five gases were determined and calculated on test mixtures. The results show that actual limits of inflammability can be closely approximated by calculation. R.A.H.

Book Review

The Calculation of Heat Transmission. MARGARET FISHENDEN AND O. A. SAUNDERS. H. M. Stationery Office. 10s. This book, issued by the Department of Scientific and Industrial Research, is of interest particularly to engineers, technologists, and students of applied science generally. As far as is possible, complicated theoretical considerations and highly specialized technical applications have been avoided, but it was thought essential to include a brief account of the fundamental physics of heat transmission. This is introduced by a simple exposition of the laws of absorption, reflection, and emission of radiation for solids and gases. Before these can be applied to practical calculations it is necessary to know the numerical values of the various coefficients, and, unfortunately, in many cases these have not been determined. Although, for instance, the radiation emitted by a "perfectly black" surface has long been known to be proportional to the fourth power of its absolute temperature and has been measured numerically, any ordinary surface emits less than a black one, and may bear very different ratios to it at different temperatures; further, different surfaces at the same temperature may emit quite different intensities of radiation, and the variations are often distressingly erratic. Anything approaching a complete survey thus offers a tedious prospect and has not been attempted; but such scattered values as could be found have been collected into a table and should enable useful estimates to be made. (*Trans. Ceram. Soc.* [Eng.])

PATENTS

Flue construction for kilns. R. H. YOUNGMAN AND R. H. H. PIERCE. U. S. 1,866,000, July 26, 1932.

Tunnel kiln. JOSEPH DANIELS (Koppers Co.). U. S. 1,866,546 and 1,866,547, July 12, 1932. W. A. HULL. U. S. 1,867,318, July 12, 1932.

Draft control for tunnel kilns. H. A. EVANS. U. S. 1,867,066, July 12, 1932. A. S. WATTS. U. S. 1,867,122, July 12, 1932.

Method of operating electric furnace. R. C. BENNER, G. J. EASTER, AND C. E. HAWKE (Carborundum Co.). U. S. 1,867,646, July 19, 1932.

Ceramic kiln. F. W. BROOKE (William Swindell & Bros.). U. S. 1,868,091, July 19, 1932.

Kiln car. P. A. MEEHAN (Swindell-Dressler Corp.). U. S. 1,871,070, Aug. 9, 1932.

Ceramic electric heating bodies. PORZELLANFABRIK KAHLA. Brit. 375,692, July 6, 1932.

Heating tunnel kilns. HOLDING-GES. FÜR KERAMISCHE WERTE. Ger. 544,792, May 17, 1930. The arrangement of the kiln and the method of circulating the hot gases are described. (*C.A.*)

Chamber kiln for firing pottery, etc. EDUARD GROSSKINSKY. Ger. 549,186, Oct. 1, 1930. (*C.A.*)

Geology

Clay and clay products. A. H. LOVELESS. *Ind. Chemist*, **5**, 185–88 (1932); abstracted in *Refrac. Jour.*, **8** [6], 240 (1932).—L. discusses the origin of various types of clay, the effect of the presence of minerals in clay on the properties of clay products, and expansion and shrinkage problems. A table is given detailing the analysis of typical English clays, in which kaolinite is regarded as the true clay substance. The impurity content of the clay increases in descending the series shown, the refractory properties decreasing simultaneously. At the temperature at which most ware is fired, tridymite is the stable form, although in firing refractories, the higher transition point may be exceeded. Although silica itself is a highly refractory material, its addition to clay does not always improve the refractory properties of the clay. E.P.R.

Chemico-genetic problem of kaolin and clay investigations. DITTLER. *Glashütte*, **62** [24], 411 (1932); *Feuerfest*, **8** [6], 99 (1932).—The chemistry and physics of kaolin and its origin and importance for ceramic technique have been studied by many investigators, but there are many complex questions which have not been answered. D. discusses the different processes of weathering such as pneumatolysis, action of hot springs, the carbonic acid theory, the formation of kaolin through humus, and ordinary weathering which all lead to the formation of clay, kaolin, and bauxite, and shows how the weathering of morasses, especially, promotes the formation of kaolin. A short description of the kaolin and refractory clay deposits of Czechoslovakia and their origin are given. M.V.K.

Geology and development of Minnesota's nonmetallic-mineral resources. G. A. THIEL AND G. M. SCHWARTZ. *Pit & Quarry*, **24** [6], 24–28 (1932).—The chief nonmetallic products are building, monumental, and ornamental stone, clay and clay products, crushed rock, sand, and gravel. Lesser products are natural cement, Portland cement, lime, marl, flint lining and pebbles for tube mills, sand-lime brick, and mineral water. E.P.R.

Nonmetallic-mineral resources and their value to South Carolina. LAURENCE L. SMITH. *Pit & Quarry*, **24** [9], 31–32 (1932).—The nonmetallic-mineral industry in S. C. is based principally upon stone, kaolin, sand, and gravel. Phosphate rock, once an important product of this state, has not been mined in several years, barite is mined at one locality, and cyanite may become important in the future. E.P.R.

Nonmetallic-mineral resources of North Carolina. H. J. BRYSON. *Pit & Quarry*, **24** [10], 17–22 (1932).—In N. C. there occur thirty-four minerals which have been produced commercially, and of this number twenty are classed as nonmetallics. They are asbestos (anthophyllite variety), barite, beryl, coal, corundum, cyanite, feldspar (orthoclase and albite), garnet (almandite and rhodolite), granite, graphite, limestone, marble, marl, mica (muscovite, biotite, and schist), monazite, pyrophyllite, quartz, soapstone, talc, and zircon. E.P.R.

Progress of the Geological Survey. W. W. WATTS. *Discovery*, **13**, 152–56 (1932).—The new museum in London provides an opportunity to trace the progress of the Survey since its inception in 1835. H.H.S.

BOOK AND BULLETINS

Microscopical Characteristics of Minerals Composing Rocks. (Mikroskopische Charakteristik der gesteinsbildenden Mineralien.) KARL CHUDOBA. Herder and Co., Freiburg im Breisgau, 1932. 18.00 Rm. Reviewed in *Sprechsaal*, **65** [25], 467 (1932).—The exact and rapid determination of mineralogical constituents which are so important for the ceramic and glass industries, and the microscopical determination of the constituents of intermediate and finished products by means of optico-microscopical research methods should be used in industrial laboratories. This book deals with feldspar, quartz, tridymite, periclase, spinel, sillimanite, corundum, etc., and presents valuable data on the determination of the refraction of light, chemical determinations of thin sections, etc. M.V.K.

Mineral Resources of the U. S., 1929. I. Metals. 968 pp. $1.50. **II. Nonmetals.** 858 pp. $1.25. Supt. of Documents, Govt. Printing Office, Washington, D. C. R.A.H.

The mineral industry. SCOTT TURNER. Bur. Mines *Information Circ.*, No. 6643. 13 pp. Free. The mineral industries in Canada and the U. S. are compared. R.A.H.

Fluorspar and cryolite in 1931. HUBERT W. DAVIS. Bur. Mines *Mineral Resources U. S.* 21 pp. R.A.H.

Preliminary report on Alabama clays. T. N. MCVAY. Bulletin published by

Alabama Industrial Development Board; *Ceram. Ind.*, **19** [1], 10 (1932).—Preliminary tests of 1500 samples of clay from all parts of Ala. indicate vast potential resources. Of these samples, 166 from 51 counties have been accepted, or tentatively so, for further study. The large variety of clays is due to the diversity of geologic formations outcropping in the state. High-grade coal measure clays, diaspore clays, and slip clays are the only ones missing from the list. The extent and commercial value of the various deposits will be investigated. Feldspar and flint do not occur in Ala. but it is possible that some substitutes may be developed. W.W.M.

Geology and coal, oil, and gas resources of the New Kensington quadrangle, Pa. G. B. RICHARDSON. Geol. Surv. *Bull.*, No. 829. 102 pp. The report describes an area of 227 square miles in western Pa. immediately north of Pittsburgh. It is estimated that 800,000,000 tons of coal remain unmined in the principal bed of this area. Several maps showing the geologic structure are included. Price 40¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. R.A.H.

Geophysical Abstracts. XXXVII. F. W. LEE. Bur. Mines *Information Circ.*, No. 6628. 25 pp. Free. A review is given of recent literature on geophysical prospecting. **XXXVIII.** *Ibid.*, No. 6638. 27 pp. Recent articles on geophysical prospecting are summarized and classified according to method. A list of recent books is given. For Part XXXVI see *Ceram. Abs.*, **11** [9], 501 (1932). R.A.H.

PUBLICATION

Sands, Clays, and Minerals. A quarterly published by A. L. Curtis, Chatteris, England. Reviewed in *Times Eng. Supp.*, **30**, 173 (1932). H.H.S.

Chemistry and Physics

Behavior of clay gels under small pressures, and the influence of the exchangeable base present. R. M. WOODMAN AND G. W. CHAPMAN. *Jour. Soc. Chem. Ind.*, **51** [23], 175–78 (1932).—A simple apparatus was devised for measuring the swelling of clays under small excess pressures. Capacity for swelling under pressure was found to depend on (1) the total base-exchange capacity of the clay or the SiO_2/Al_2O_3 ratio, (2) the base saturating the clay, and (3) the age of the clay suspension used in the experiments. A hysteresis in subsequent swelling probably occurs on reduction of the pressure to which a clay has been subjected. G.R.S.

Hydrogen-ion concentration of ferric hydroxide sols. WINIFRED L. MCCLATCHIE. *Jour. Phys. Chem.*, **36** [7], 2087–94 (1932).—Apparent hydrogen-ion concentrations as given by hydrogen, glass, and quinhydrone electrodes were compared, using sols of ferric hydroxide. Results with glass and quinhydrone electrodes agree, but hydrogen electrodes gave low and erroneous results. G.R.S.

Drying of solids. Application of diffusion equations. T. K. SHERWOOD. *Ind. Eng. Chem.*, **24** [3], 307–10 (1932).—In the drying of a solid slab, the moisture distribution approached during the constant rate-of-drying period is represented by a parabolic function of the distance from the surface. The equation is given, expressing the relation between moisture content and time in the drying of a solid slab with internal liquid diffusion controlling, for the case of an initial parabolic moisture distribution. Data are presented supporting the applicability of this relation to the drying with internal liquid diffusion controlling subsequent to a preliminary constant-rate period. R.G.M.

Determination of the capability of absorption of water by ceramic bodies according to different methods. GÜNTER HAMMER. *Sprechsaal*, **65** [26], 471–72 (1932).—H. discusses and compares (1) the methods of the German Ceramic Society (*Ceram. Abs.*, **6** [8], 361 (1927)), (2) the same method with a subsequent boiling of the samples, and (3) the vacuum method. Investigations show that when the bodies have a porosity of about 10% or more, the difference between the separate methods is smaller. If the capability of absorbing water is less than 10%, the difference increases with decreasing porosity. If the capability of absorbing water amounts to 1% or less, an exact determination is no longer possible. The vacuum method gives more exact values than boiling in water and takes less time. Bodies do not reach a complete saturation through boiling in water and the vacuum method should be used for determining the apparent and true porosity. M.V.K.

Effect of particle size of materials on their melting temperatures. N. SCHOORL. *Z. physik. Chem.*, **A160** [3–4], 158–60 (1932).—The phenomenon of Pavlov, that the melt-

ing temperatures of certain finely divided materials are lower than those of coarser particles of the same material, is substantiated but interpreted differently. It may be due to (1) contact with a thin devitrified surface of the glass vessel which causes the lowering, or (2) impurities of the substance which are detached from thin surfaces. L.T.B.

Regular families of curves. I. HASSLER WHITNEY. *Proc. Nat. Acad. Sci.*, **18** [3], 275–78 (1932). II. *Ibid.*, **18** [4], 340–42 (1932).—A new definition of the function, μ, is given. A condition for the regularity of a family of curves is stated and theorems are given on the covering by a set of "tubes" of an "extended family of curves" formed by adding a closed set of "invariant points" to a regular family of curves. J.L.G.

Constitution of silicates in the light of crystallographic investigations of the structure. W. EITEL. *Glashütte*, **62** [24], 410–11 (1932).—As a result of the latest investigations in crystallography, the spatial constitution of almost all important types of silicates has been studied. Of special importance is the discovery that the relatively large atom of oxygen determines the true type of the lattice in silicates according to the principle of "ball packing" and not the small atoms of silicon and aluminum. The simplest configuration of the SiO_4-tetrahedron is found, in its purest form, in the orthosilicates of the olivine group. Further types are derived from this group through the linking of the tetrahedron into unidimensional structures or formations of the so-called "metasilicates" of the pyroxene and amphibole groups. The SiO_4-tetrahedrons may, however, be arranged into net-shaped level groups as is observed in the structure of mica. Ultramarine and sodalite (Jager), zeolite analcine (Taylor), feldspar types (Schiebold), and their aluminosilicates have the most peculiar spatial configurations. In such coarse-meshed structures, the most varied kinds of atoms and their groups may occur without endangering the cohesion of the lattice structure. The ideal simplest spatial mesh nets show the different modifications of silicon, while in aluminosilicates besides the SiO_4 group, the AlO_4 group may appear because aluminum like silicon is a small element in comparison with oxygen. Aluminum can show, besides the coördination with 4 oxygen atoms to a tetrahedral group, an octahedral coördination with 6 oxygen atoms and in andalusite, even 5. On the variability of this configuration is based the interesting relationship of the 3 modifications of aluminum silicate, Al_2O_3-SiO_2. Due to this fact the substitution of a silicon atom in the lattice of sillimanite by an aluminum atom is the peculiar reason for the confusing similarity of the lattice of the technically important mullite with natural sillimanite. In all cases of the substitution of elements of approximately the same size in a silicate lattice, the basic laws of the formation of crystals are confirmed as has been advanced by Goldschmidt in his researches on the problem of isomorphism. Not only the similarity of the atomic diameter, but also the analogy of the finer atomic structure, and especially the electric charging of ions determine the substituting elements. The validity of such assumptions is approved by the constitution of numerous natural mixed crystals of silicates, *e.g.*, in triclinic feldspars, augites, hornblendes, micas, etc. Even the peculiar phenomenon of the spontaneous enrichment of rare elements such as gallium and germanium in aluminosilicates is explained undoubtedly by extending the assumptions concerning the isomorphism of silicates. M.V.K.

Thermal expansion of some silicates of elements in Group II of the periodic system. R. F. GELLER AND HERBERT INSLEY. Bur. Stand. *Jour. Research*, 9 [1], 35–46 (1932); R.P. 456.—A ceramic body having the unusually low average coefficient of linear thermal expansion of 0.53×10^{-6} in the range 0 to 200°C, reported by W. M. Cohn, was investigated, and it was found that this material is composed essentially of the mineral cordierite. This mineral may be prepared by sintering a mixture of talc, clay, and corundum at 1350°C, although the time required is considerably shortened by heating at from 1400 to 1425°C. At temperatures above 1425°C decomposition of the cordierite will take place. It may be formed also by devitrification of a glass of the proper composition at temperatures above 950°C and below about 1425°C. The investigation was amplified to include thermal expansion determinations for some compounds of other elements in Group II of the periodic system. The data obtained indicate that zinc orthosilicate, celsian, and beryl appear worthy of consideration in the development of bodies having low coefficients of thermal expansion. R.A.H.

Theory of the silicate residues of blast-furnace slags. C. D. ABELL. *Ind. Chemist*, **8**, 110–13, 128–30, 191–94 (1932).—Prior to the melting phase in the hearth the slag is gehlenitic in character; on the hearth and later it becomes more or less akermanitic according to the concentration of Al_2O_3 and MgO, and on further cooling spinel crystallizes in primary form succeeded by tetragonal gehlenite, $2CaO,Al_2O_3,2SiO_2$, and aker-

manite, $2CaO,MgO,2SiO_2$, in varying proportions. A comprehensive review of the ternary systems involved is given, particularly with reference to cold-blast working. (*B.C.A.*)

Ternary system, sodium sulphate–sodium carbonate–water. N. S. KURNAKOV AND S. S. MAKAROV. *Ann. inst. anal. phys.-chim.* [Leningrad], **4** [2], 307–63 (1930); abstracted in *Glastech. Ber.*, **10** [4], 216–17 (1932).—It was found that pure salts can not be obtained from a watery solution of sodium sulphate and sodium carbonate at room temperature. The most unfavorable temperature for obtaining pure soda from these solutions lies between 25 and 50°C. The $Na_2CO_3{\cdot}10H_2O$ or $Na_2CO_3{\cdot}H_2O$ precipitated within this temperature interval contains about 2% by weight of sodium sulphate. M.V.K.

Damage caused by sodium sulphate. A. W. RICK. *Tonind.-Ztg.*, **56** [51], 649 (1932).—This is a discussion of a paper by Dawihl (see *Ceram. Abs.*, **11** [8], 454 (1932)). Some experiments are mentioned in which crystallization took place under water, thereby causing an explosive action. W.M.C.

Combination of carbon monoxide and oxygen under the influence of radon. S. C. LIND AND CHARLES ROSENBLUM. *Proc. Nat. Acad. Sci.*, **18** [5], 374–86 (1932).—The authors investigated the extent to which carbon dioxide influences the rate of α-ray reaction in which it is produced by the union of oxygen and carbon monoxide. Only about 14.5% of the ionization falling upon CO_2 was found to be chemically active. J.L.G.

Rapid determination of silica. ANON. *Tonind.-Ztg.*, **56** [47], 597–98 (1932).—The progress in methods for the determination of silica is reviewed. W.M.C.

Gravimetric method for the separation and determination of titanium. H. T. BEANS AND D. R. MOSSMAN. *Jour. Amer. Chem. Soc.*, **54** [5], 1905–11 (1932).—Titanium is precipitated as a double potassium titanium iodate. R.G.M.

Detection of very small quantities of vanadium. FRITZ EPHRAIM. *Helv. Chim. Acta*, **14**, 1266–69 (1931); abstracted in *Analyst*, **57**, 126 (1932).—The new method for the detection of V, said to exceed all previous methods in accuracy, is based on the reaction, $V^{\cdots\cdot} + Fe^{\cdots} = V^{\cdots\cdot\cdot} + Fe^{\cdots}$, which goes from left to right in alkaline solution and in the reverse direction in acid. The ferrous ion is detected by the dimethylglyoxime reaction. To make this reaction specific for V, it is necessary to boil the solution with HCl which reduces the $V^{\cdots\cdot\cdot}$ but not the ferric ion. When working with small quantities of V it is advisable to use HBr instead of HCl. The $FeCl_3$ solution should be cold and not over 3 days old to prevent its dissociation into $FeCl_2 + Cl_2$ which takes place especially in very dilute solutions in the presence of sufficient air and light. Other metallic ions do not hinder the reaction, except large amounts of Ni, Co, Mn, and Cu, which are removed by boiling with NaOH. J.G.T.

Detection of heavy metals by means of the drop reaction with dithizon. H. FISCHER. *Wiss. Veröffentlich. Siemens-Konzern*, **10** [2], 99–107 (1931); *Glastech. Ber.*, **10** [4], 229–30 (1932); for abstract see *Ceram. Abs.*, **10** [8], 604 (1931). M.V.K.

Determination of relative humidities by means of thermocouples. J. H. LANNING. *Ind. Eng. Chem.* [Anal. Ed], **4** [3], 286–87 (1932). R.G.M.

X-ray as a research tool in chemistry and industry. G. L. CLARK. *Ind. Eng. Chem.*, **24** [2], 182–90 (1932).—The properties of X-rays which may be applied for research purposes are briefly reviewed. R.G.M.

New tools for high-temperature research. R. B. SOSMAN. *Ind. Eng. Chem.*, **23** [12], 1369–74 (1931).—S. presents a general discussion of important factors in high-temperature work. R.G.M.

Unification of the term, "viscosity." C. H. WEISS AND PAUL WOOG. *Chim. & ind.* [Special No.], pp. 278–96 (March, 1932); for abstract see *Ceram. Abs.*, **11** [9], 506 (1932). (*C.A.*)

International comparison of electrical standards. G. W. VINAL. Bur. Stand. *Jour. Research*, **8** [6], 729–49 (1932).—Extended comparisons were made in 1931 of standards for the international ohm, ampere, and volt as maintained by the national laboratories of Germany, England, and the U. S. R.A.H.

BOOKS

Colloid Chemistry, Theoretical and Applied. Vol. IV. Technological Application. II. JEROME ALEXANDER. Chemical Catalog Co., New York. 734 pp. Price $11.50. *Can. Chem. Met.*, **16** [7], 43 (1932).—This volume concludes the monumental collection of colloidal chemical data which consists of over 200 papers, covering practically every phase of the theory and applications of colloidal chemical principles. For Vol. III see *Ceram. Abs.*, **11** [4], 282 (1932). E.J.V.

Gmelin's Handbook of Inorganic Chemistry. (Gmelin's Handbuch der anorganischen Chemie.) Edited by R. J. MEYER. 8th ed., System-Number 7, Bromine. 342 pp. Verlag Chemie, Berlin, 1931. Reviewed in *Jour. Phys. Chem.*, **36** [7], 2107 (1932). G.R.S.

PATENTS

Manufacture of chromium oxide. BERNHARD WURZSCHMITT (I. G. Farbenind. A.-G.). U. S. 1,866,608, July 12, 1932. A method for producing chromic oxide comprises mixing an alkali metal chromate with such an amount of phosphorus as causes the formation of alkali metal phosphate only, igniting the mixture, and separating the chromic oxide from the alkali metal phosphate by dissolving the reaction mixture in water and filtering off the chromic oxide from the potassium phosphate lye.

Purification of ceramic materials by sodium cyanide. E. A. SLAGLE (American Smelting and Refining Co.). U. S. 1,866,727, July 12, 1932. (1) The process of purifying opacifying agents used in enamels, glazes, and glasses to remove impurities therefrom which are capable of introducing an undesirable color into the finished product comprises treating the opacifying agents with a cyanide solution whereby the undesirable materials are dissolved and separated therefrom, and then removing the opacifying agents from the solution. (2) The process of purifying sodium antimonate comprises leaching it with sodium cyanide in the presence of an amount of sodium hydroxide sufficient to impart an alkalinity to the solution and to retard the hydrolysis of the cyanide.

Manufacture of barium compounds. SERGE WITTOUCK (International Industrial and Chemical Co., Ltd.). U. S. 1,869,454, Aug. 2, 1932. In the manufacture of a barium silicate compound, the method comprises providing a mixture including silicon in oxy-compound form and a compound of barium fusible at a temperature requisite to reaction thereof with silica to form the silicate and calcining the mixture while dispersed in a quantity of the barium silicate compound.

Production of barium aluminate. H. W. HEISER (Aluminum Co. of America). U. S. 1,871,056, Aug. 9, 1932.

General

Brush-shifting a.c. motors. E. A. GREEN. *Maintenance Eng.*, **90** [6], 245–48 (1932).—An adjustable speed, a.c., brush-shifting motor has the speed-load characteristics of a d.c. shunt motor together with smooth variations in a 3 to 1 speed range. The construction, characteristics, and applications of such a motor are explained. Illustrated. J.L.G.

What automatic motor control means to the maintenance engineer. F. L. SPANGLER. *Maintenance Eng.*, **90** [7], 281–83 (1932).—Illustrated. J.L.G.

Lubricating systems. Mechanical purifiers. FRED H. LOW. *Maintenance Eng.*, **90** [6], 249–50 (1932).—Mechanical purifiers operating on the centrifuge principle are described and their operation is explained. Illustrated. See also *Ceram. Abs.*, **11** [6], 378 (1932). J.L.G.

Heat balance of steam brick plants. ANON. *Deut. Ziegel-Ztg.; Rev. mat. constr. trav. pub.*, No. 273, pp. 101–105*B* (1932).—A detailed discussion of the heat generated and lost and the calculation of the heat balance is given. M.V.K.

Industrial unit heaters. CARL HEYEL. *Maintenance Eng.*, **90** [7], 284–86 (1932).—Isolated diffusing unit heaters for industrial plants are described. Illustrated. J.L.G.

Hot air drying plant. C. GALLAUS. *Tonind.-Ztg.*, **56** [53], 669–71 (1932).—Details are given of a new drying plant using hot air which is claimed to operate very economically. Illustrated. W.M.C.

Plant illumination. CARL HEYEL. *Maintenance Eng.*, **90** [6], 251–54 (1932).—The value of definite foot-candle standards for lighting and the use of paint as an illumination tool in the factory are stressed. Illustrated. J.L.G.

"Feather joints" as indicators of the direction of movements on faults, thrusts, joints, and magmatic contacts. ERNEST CLOOS. *Proc. Nat. Acad. Sci.*, **18** [5], 387–95 (1932).—The paper describes a series of experiments conducted with wet clay which make clear the origin and interpretation of "feather joints," especially in relation to the stress-strain ellipsoids. J.L.G.

Hard facing adds to equipment life. E. H. HUBERT. *Factory & Ind. Management*, **83** [7], 277–78 (1932).—Advantages of facing wearing parts with hard metal are discussed. E.C.C.

Ceramic ware fired in gas-fired periodic kilns. ANON. *Fuels & Fur.*, **9** [6], 731–32 (1931).—At the Federal Tile Co., Columbus, Ohio, ceramic floor tile and faience are fired in eight periodic type gas-fired kilns. A general description of plant procedure, the drier, press room, and kilns is given. Illustrated. E.J.V.

Water conduct in clay pits. FISCHER. *Tonind.-Ztg.*, **56** [55], 696–98; [57], 720–22 (1932).—Different methods for removing the water in clay pits are outlined. W.M.C.

Milling feldspar at Spruce Pine. B. C. BURGESS. *Ceram. Age*, **18** [3], 155–68 (1931); for abstract see *Ceram. Abs.*, **10** [10], 729 (1931). R.G.M.

Individual and group drives. Investment and operating cost data. I. ROBERT DRAKE. *Maintenance Eng.*, **90** [6], 237–42 (1932).—This is the first of a series of five articles on the merits of the use of individual drives as compared with group drives. Illustrated. **II.** *Ibid.*, **90** [7], 287–92 (1932).—The fundamental reasons for differences in first cost and operating costs between group and individual drives are (1) the higher first cost, maintenance cost, and repair cost per horse power as well as poorer electrical performance and lower reliability of motors and like equipment in small sizes as compared with larger sizes; (2) for both individual and group drives the total connected motor load exceeds the maximum demand and this excess is far greater for individual than for group drives. With skilful engineering, this excess is ordinarily 10 to 25% for group drives. For individual drives, it is ordinarily 200 to 250% where most of the machines work continuously at a single job. It rises to 350 or 400% where the work approaches jobbing in variety. This excess increases the smaller the motor used. The reasons for the second item are discussed. Illustrated. J.L.G.

Maintenance order systems. VI. Where shall the maintenance dollar be spent? G. I. Ross. *Maintenance Eng.*, **90** [6], 257 (1932). **VII. Prophesying maintenance costs.** *Ibid.*, **90** [7], 293–94 (1932).—Typical order forms are reproduced. J.L.G.

Treatment and upkeep of brick plant equipment. THOMAS. *Tonind.-Ztg.*, **56** [51], 644–45 (1932). W.M.C.

Periodic inactivity complicates motor maintenance. E. MOLINET. *Maintenance Eng.*, **90** [6], 243–44 (1932).—Illustrated. J.L.G.

Redundant factories. ARTHUR BALFOUR. *Times Eng. Supp.*, **30**, 137 (1932).—The danger of establishing more plants than are needed is apparent in new countries that are embarking with more zeal than discretion on a policy of self-containment. H.H.S.

Federation of ceramic trade associations. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **11** [8], 197–99 (1932).

Promotion of ceramic products. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **11** [8], 199–200 (1932).

Why American pottery is not the vogue in America. R. C. PURDY. *Ceram. Age*, **18** [4], 220–21 (1931). R.G.M.

Standardization in the glass and porcelain industries in U.S.S.R. A. D. BOGOSLOVSKI. *Ceramics & Glass*, **8** [3], 22–27 (1932).—B. discusses the plan of standardization of the glass and porcelain industries and its achievements during the last few years. The whole production is classified according to the kinds of ware. An index of the standards adopted and worked out is given. M.V.K.

Ceramic industry of Russia. OSKAR LECHER. *Ber. deut. keram. Ges.*, **13** [5], 185–95 (1932).—A general discussion of the various branches of the ceramic industry in U.S.S.R. is presented. E.J.V.

New Jersey clayworkers hold summer meeting. ANON. *Clay-Worker*, **98** [1], 17 (1932).—The new name of the organization is the Ceramic Assn. of New Jersey, and the chief topic of discussion at the June 17 meeting was marketing problems. E.J.V.

Meeting of the German Technical High School in Prague. ANON. *Glashütte*, **62** [21], 355 (1932); *Tonind.-Ztg.*, **56** [55], 700–701 (1932).—The following papers were discussed: (1) "Processes of the softening interval of amorphous, vitreous materials," by Tammann (see p. 520, this issue); (2) "Constitution of silicates in the light of crystallographic structure investigations," by Eitel (see p. 542, this issue); (3) "Chemicogenetic problems of kaolin and clay investigations," by Dittler (see p. 540, this issue); (4) "Theory of the glassmelting art" and "Glass manufacture," by Zschimmer; (5) "Magnesite as raw product," by Redlich; (6) "Silica brick," by Endell; (7) "Grog brick," by Robitschek; (8) "Highly refractory special materials," by Endell; (9) "Chemical and physical properties of magnesite brick," by Miksh; (10) "Formation, constitution, and properties of porcelain," by Rieke; (11) "Power and heat efficiency in glass and porcelain industries," by Breinl; (12) "Technique of firing and kiln construction in the glass and porcelain industries," by Kanhäuser; (13) "Pulverizing and preparing porcelain earth," by Haumeder. M.V.K.

New York State College of Ceramics. ANON. *Clay-Worker*, **98** [1], 11–13 (1932).—A brief description of the new building and a summary of changes in the teaching staff are presented. Illustrated. E.J.V.

New ceramic patents. K. GROYEN. *Tonind.-Ztg.*, **56** [53], 671 (1932).—G. discusses the paper by Hirsch (see *Ceram. Abs.*, **11** [9], 508 (1932)). W.M.C.

BOOK AND BULLETINS

The Law of Patents for Chemists. J. ROSSMAN. ix + 304 pp. Inventors' Publishing Co., Washington, D. C., 1932. Price $3.50. Reviewed in *Jour. Amer. Leather Chem. Assn.*, **27**, 137–38 (1932).—R. is patent examiner of chemical inventions in the U. S. Patent Office. H.H.S.

Factors governing the selection of the proper level interval in underground mines. WILLIAM O. VANDERBURG. Bur. Mines *Information Circ.*, No. 6613. 17 pp. Free. Some mines after passing through the prospecting stage and becoming sizable enterprises still adhere to the development program of the prospect, extending their workings without definite plans. A lack of definite plans for laying out mine workings is one of the contributory factors to unnecessarily high costs. Although this paper deals primarily with the influence of level spacing on mining costs, other phases of mine development can be analyzed on a cost basis in a similar manner as shown. R.A.H.

Iron oxide pigments and mortar colors. R. M. SANTMYERS. Bur. Mines *Information Circ.*, No. 6627. 26 pp. Free. The report gives a general description of the coloring agents and describes the properties, uses, substitutes, sources, mining and preparation, production, imports, exports, and prices. A list of producers and dealers of iron oxide pigments is included. R.A.H.

Sampling and estimation of ore deposits. C. F. JACKSON AND J. B. KNAEBEL. Bur. Mines *Bull.*, No. 356. 155 pp. 15¢. Methods to be employed, pitfalls to avoid, and examples of modern practice are given. R.A.H.

Milling methods and costs at the Hillside fluorspar mines, Rosiclare, Ill. EDWIN C. REEDER. Bur. Mines *Information Circ.*, No. 6621. 20 pp. Free. See also *Ceram. Abs.*, **10** [2], 145 (1931). R.A.H.

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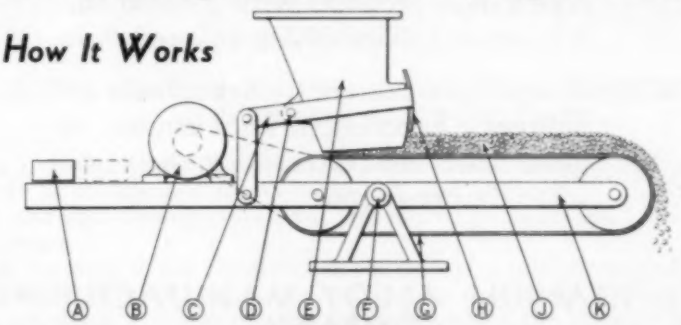

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BULLETIN

of the

AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific, and Art Questions, and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 11 **October, 1932** **No. 10**

EDITORIAL

ARGUMENT AGAINST EXCLUSIVE DEVOTION TO SCIENTIFIC AND TECHNICAL KNOWLEDGE

The Constitution of this SOCIETY states that "the objective of the SOCIETY is to advance the ceramic arts and sciences . . ." This is a single and exclusive objective, yet two-fold in its direction, (*a*) arts, and (*b*) sciences.

That sentence in the Constitution continues ". . . by meetings for reading and discussion of papers, the publication of scientific literature, and other activities." These are the means by which the SOCIETY is to advance the ceramic arts and sciences.

The "other activities" by which the SOCIETY should be advancing the ceramic arts and sciences follow:

(1) Promotion of ceramic research and education for the purpose of creating ceramic information, fundamental and applied, is one of the "other activities" in which from the beginning this SOCIETY has been engaged.

(2) Promotion of ceramic research in federal and state ceramic bureaus, surveys, and universities has been successfully prosecuted by the SOCIETY.

(3) Organization of state ceramic associations with research and

educational programs has been proposed and in some instances developed with significant success. In Ohio such an organization was successfully promoted by this SOCIETY.

(4) Collaboration with other societies by joint committees and by appointed committee memberships on ceramic problems has been successful to a remarkable extent.

(5) Securing the interest of ceramic trade associations in technological research has resulted in the production of a great deal of recorded useful knowledge, the most notable being the kiln studies. The Refractories Institute and the Terra Cotta Society have had established formal collaboration with this SOCIETY, the technical committees and meetings being under joint auspices. The National Brick Manufacturers' Association reorganized into a Research Foundation with an organic tie-in with this SOCIETY.

(6) Several special studies have been developed in symposiums, the sponsorship and financing of which were designedly left to the trade associations. For illustration, the sagger studies by the United States Potters' Association, the feldspar standards by the Feldspar Institute, and quality tests by the Vitrified Pottery Manufacturers in collaboration with the hotel and restaurant associations.

(7) Promotion of standardization of ceramic materials and products and the development of standard test apparatus and methods has been prosecuted energetically under the auspices of the SOCIETY's Committee on Standards, and in collaboration with other associations and governmental agencies.

(8) Collecting and codifying data has been done to some extent. Coöperation through the National Research Council in compiling the annual tables of data has been continued for several years.

(9) Exhaustive bibliographies have been compiled and published on refractories and enamels, and several short bibliographies on other special subjects. These bibliographies and book lists are essential to profitable research.

That the above "other activities" come within the scope of the objects as stated in the Constitution of this SOCIETY there has been no question. These objectives have always been recognized. They are not new. They are essential to the obtaining and applying of knowledge. They are academic in character.

When this SOCIETY was first organized its activities were wholly academic in character. This was a reflection of the prevailing idea of research, even industrially. The scope of industrial research naturally and rightly was extended to production control, to product development, and product promotion. The industrial research laboratories are today finding a place with the sales department analogous with the place they have had with the production departments. The industrial laboratories, fundamental, applied, and control, have the needs of the customers and the sales possibilities as their end objectives and concern. The laboratories are today working as intimately with the sales department as they have worked and still are working with the production departments.

Research is no longer purely academic. With this broadening in scope and direction of attention in industrial research laboratories

there has been the same broadening in scope and in direction of the industrial technical societies, such as the AMERICAN CERAMIC SOCIETY.

To include product development and promotion with the "other activities" is not making the SOCIETY a "glorified trade association," as some have said. The facts are that the industrial technical society that does not give attention to product development and promotion is dwarfing its capacity to function in the purely academic activities.

This whole question was stated forcefully by our revered General Edward Orton, Jr., in his presidential address, a few paragraphs of which follow. We recommend a re-reading of that entire masterful address.[1]

May we now, then, justly say that we have been attaining through the years those initial objectives which we set for ourselves? May we not say more, that we have made a brilliant and impressively successful record, and that we have won the recognition and praise of the great technical societies in their respective fields of science and technology?

There is now urgent need of a reconsideration of our objectives. To the soldier or statesman, the attainment of one objective means the setting up of another. Nothing remains static in this world, nor in the great cosmos of which it is an infinitesimal speck. We must continue to grow and expand, or we shall inevitably shrink and die. Our early objectives have been so largely attained that there is a real and present danger that we may go stale if we do not address ourselves to a new task which will give outlet to our activities and put to a fresh test the initative, driving force, and altruistic purpose which animated our early years.

What should the new objective be? Opinions may well differ upon this. I will give you my own. I think the SOCIETY should now definitely set itself to serve (more directly) the ceramic industries on their business side. They think of us now as a group of technical men who read papers to each other. They do not visualize in us a powerful and resourceful ally to bring in more business or to make their present business more profitable.

What do the ceramic industries of the United States need? Most of all they need to develop unity of purpose, and ability to coöperate as a group for putting the ceramic industries boldly and broadly before the people. Other groups are doing this in their fields, especially our leading competitors, steel, cement, chemical products, and wood products. They have been able to sink their internal differences and unite in common programs to boost their work. Not so with us.

The great groups of ceramic industries need aggressive leadership of national character to represent their products. They need representation in the places where standards are set and specifications are drawn. They need representation in government departments, where promotion plans are made and public questions are answered. They need sustained and intelligently developed publicity through which the people may be forced to learn the merits of what is produced, and the value of the services their products can render.

What has the AMERICAN CERAMIC SOCIETY done to bring about this unity of purpose and coöperation in the ceramic industries? Very little in any specific direction. Our mere existence has been a useful influence, though passive in character and, if these ideas are sound and practical and are generally recognized, why have we not stepped into the breach and made ourselves felt? Has it been lack of vision of the need and of our opportunity? In part, yes. But there are among us quite a few who have seen this picture and have lifted their voices, like the prophets of old, calling aloud in the wilderness. Chief among these has been our able Secretary, Mr. Purdy, who never loses a chance to express this idea. But, as a body we have not seen this picture, or if we have seen it, we have done little about it.

But the one big obstacle which has held us back is not so much lack of vision as it is lack of resources. And why do we lack resources? Because we have not yet convinced business executives that we are anything more than a body of technical men.

We have made better technique possible. We have made research and its fruits

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[1] See *Bull. Amer. Ceram. Soc.*, **10** [4], 76 (1931).

available. Now, we must go further and show industry how to use research. We must translate research into new products and better products, and do our share by promotion to educate the public to accept and use them. When we can show plant managers and corporation heads that our work powerfully and directly aids in making new products and new markets, or even helps to hold their place against the aggressive inroads of competing industries, then they will not let us suffer for lack of resources.

Thus, as I vision it, the SOCIETY finds itself in a vicious circle. We can not do things in a big way for lack of funds. We can not get funds because we do not do things in a big way.

We have to find a way to break out of this circle. We have no reason for discouragement. The problem we face now is not one-tenth as difficult as that which we confronted when we organized thirty-three years ago.

ACTIVITIES OF THE SOCIETY

OUR ANNUAL MEETING

Week of February 12, 1933, Hotel William Penn, Pittsburgh, Pa.

I. The tentative program outline has been submitted as follows:

Sunday, February 12

Morning or afternoon, or both, meeting of the Board of Trustees.

8:00 P.M. Reception, Silver Room, William Penn Hotel (this room accommodates 125 people).

8:30 P.M. Entertainment, Urban Room, William Penn Hotel (this room accommodates 650; about 600 members are expected on Sunday evening).

Monday, February 13

10 A.M. General meeting, Urban Room (if this is not sufficiently large the Major Ballroom which accommodates 1000 on the main floor and 1500 with the balcony can be used). On this occasion there will be a word of welcome from H. H. Blau, Chairman of the Pittsburgh Section, President Poste, and several "bang-up addresses" by outstanding individuals.

12 M. General luncheon for all members of the SOCIETY.

2 P.M. Division meetings.

8:30 P.M. Frolic and dance, Major Ballroom, under auspices of Materials and Equipment Division.

Tuesday, February 14

9:30 A.M. Division meetings.

12 M. Division luncheons.

2 P.M. Division meetings.

8 P.M. Urban Room or Major Ballroom, public lecture by Dr. A. L. Day, under auspices of the Fellows.

Wednesday, February 15

9:30 A.M. Division meetings.

12 M. Division luncheons.

2 P.M. "See Pittsburgh" tour.

8 P.M. Theatrical performance, The Little Theatre, Carnegie Institute of Technology.

Thursday, February 16

10 A.M. General business meeting. Induction of officers.

12 M. General luncheon.

2 P.M. Meeting on Business Management.

6 P.M. Dinners for special groups.

Friday, February 17

Plant Visits.

2. The Divisions are building their programs.

3. The industrial conditions are improving.

4. Producers of competitive products are active in research development and promotion.

5. To hold their markets, the ceramic industries must be alert in finding materials and processes that will produce the best at the lowest cost.

6. This 1933 Annual Meeting will be a revival meeting—good alike for saint and sinner.

GLASS DIVISION FALL MEETING

Members of the Glass Division of the AMERICAN CERAMIC SOCIETY are planning to hold their annual Fall Meeting on October 8 at the Woodmont Rod and Gun Club near Hancock, Md. The Club charge will be $3.50 per day including meals, and accommodations are being made for at least twenty-five persons.

The place is primarily a hunting preserve. It is in the woods away from civilization and on the bank of the Potomac River (an inland Cove Point, so to speak). For the benefit of those who attended the meeting last year at Old Point Comfort it is announced that "coats will not be required in the Club dining room."

The Club is located in the center of a glass sand and mining territory and visits have been planned to one or more of the adjacent properties.

The Club is easy of access, being about five miles west of Hancock, Md., on the National Pike (U. S. No. 40). The camp is equipped with radio, piano, horse-shoes, fishing-tackle, and it will not be necessary to bring blankets.

Reservations should be made with Secretary Jack H. Waggoner, Mellon Institute, Pittsburgh, Pa. Any "overflow" of guests will be taken care of in the nearby towns of Hancock or Berkley Springs.

NECROLOGY

Mrs. Francis W. Walker

Older members of the AMERICAN CERAMIC SOCIETY will be grieved to learn of the death of Mrs. F. W. Walker at her home in Beaver Falls, Pa., on August 4, 1932.

I. F. Dains

I. F. Dains, president of the Western Stoneware Company, of Monmouth, Illinois, died at St. John's Hospital, Springfield, Illinois, on September 7, 1932. Mr. Dains had been a member of the AMERICAN CERAMIC SOCIETY since 1919 and later represented his company with a corporation Membership.

Paul E. Cox, head of the Department of Ceramic Engineering, Iowa State College Ames, Iowa, has commented on Mr. Dains' activities in the following communication:

"Mr. Dains headed one of the largest surviving stoneware producing concerns. Monmouth clay is known to every studio potter in the land even though the clay really came from close to Macomb, Illinois. He was ever friendly toward the amateur working in ceramics.

I knew the Monmouth Pottery Company when it was headed by a man with no sense of honor in his business dealings and have known the Western Stoneware Company which had for its largest plant the Monmouth Pottery. I. F. Dains broke down the unsavory name of the organization and by decent treatment of employees and customers built a monument for all who earned a livelihood from the manufacture of stoneware in his chain of factories."

W. L. Ellerbeck

W. L. Ellerbeck, of the Utah Lime and Stove Company, Salt Lake City, Utah, passed away on August 12, 1932. Mr. Ellerbeck had been a member of the AMERICAN CERAMIC SOCIETY since 1919.

Carl O. Daniels

Carl O. Daniels, President of the Greendale Brick Co., Columbus, Ohio, died in September, 1932, in Columbus. His death was the result of an infection resulting from an abscess in one of his lungs, beginning four years ago. Mr. Daniels had been a member of the AMERICAN CERAMIC SOCIETY for about four years.

NOTES AND NEWS

E. H. MAX VON VOPELIUS

With the Deutsche Glastechnische Gesellschaft and the many personal friends and admirers here and abroad, the members of the AMERICAN CERAMIC SOCIETY mourn the loss of the generous and profoundly helpful friend and associate, E. H. Max von Vopelius.

When the members of the AMERICAN CERAMIC SOCIETY visited abroad, Dr. Vopelius was generous in his time and influence in planning and in making our tour successful in Germany.

His many contributions to the art and science of glassmaking and his astute organiz-

ing and magnetic personality, which in ten years have caused the Deutsche Glastechnische Gesellschaft to develop and achieve an ambitious program of activities and a production of scientific and technical information beyond the ordinary achievements, made for him a world-wide reputation and friendship.

In memory of Dr. Vopelius, the Deutsche Glastechnische Gesellschaft has issued a memorial brochure from which the following notice is taken.

MAX VON VOPELIUS

Biography

Max von Vopelius was born July 27, 1872, in Sulzbach (Saar) as the son of a glassworks proprietor, Richard v. Vopelius, and his wife, Helene v. Ammon. His graduation from high school at Saarbrücken in March, 1892, was followed by seven semesters of study in chemistry, law, and political economy at the Universities of Heidelberg, Berlin, and Halle, hearing men like Dilthey, Quincke, Schmoller, Sering, Conrad, Treitschke, and Wagner. In 1895 he received his Doctor's degree at the Halle University on the dissertation, "The Table-Glass Industry in the Saar Valley." In connection herewith he took a study trip to the U. S. In coöperation with Leo Wentzel he brought about an amalgamation of the table-glass industry in the Saar Valley.

Dr. Vopelius became President of the Association for the Protection of Industrial Interests in the Saar in 1926. He was also President of the Saar Territory Employers' Association and a member of the Councils of the Empire Association of German Industries and of the German Sheet Glass Employers' Association. In 1922 he was active in the founding as well as President of the Wärmetechnische Beratungsstelle (Technical Advisory Board on Heat Problems) and effected and headed the organization of the Deutsche Glastechnische Gesellschaft in 1923. In 1925 he was elected a member of the English Society of Glass Technology.

In Memoriam

The news of the death of our greatly esteemed President on Wednesday, July 13, did not find us entirely unprepared. All during the past year Max von Vopelius had been ill and unable to discuss his many professional and honorary duties with energy. Compelled to remain bedfast he followed closely and with the greatest interest all the happenings of the Deutsche Glastechnische Gesellschaft and the Wärmetechnische Beratungsstelle, until his powers failed him and death came to bring relief after a suffering without complaint. Those who knew him had forseen the inevitable but the final realization stirred everyone to deepest sorrow.

The Pyrometric Council of the German Glass Industry (Wärmetechnische Beratungsstelle der Deutschen Glasindustrie) and the German Society of Glass Technology (Deutsche Glastechnische Gesellschaft) owe much, if not everything, to Dr. Vopelius. It was he who had vision enough, even before the War, to realize that the glass industry could survive only if it would open its closed doors to science and engineering. This man, though president of a Society and co-owner of glassworks, was not concerned in gaining advantages for his own interests. He placed service and care for the general welfare above everything else. The great respect and unbounded confidence which Dr. Vopelius enjoyed in the circle of his colleagues, government officials, co-workers, and friends have set the pace for others to follow on the track of the great ideas for which he stood with all his personality. Unhesitatingly it was his endeavor to clarify and teach by word and script even though meeting deaf ears. Only a man of his ability and knowledge, balanced by a strong character and integrity, could obtain such pacifying results. Wherever he went, Dr. Vopelius was a dignified man of the world, and in his modesty and reserve, without the least claim for recognition, he might well serve as an example.

In the advancement of technology and as a guide of science he became in Germany a pioneer of the Fourcault process. Perhaps hardly any other industrialist has occupied himself to such a degree with the technical details of a process. It was this penetration into the weaknesses and difficulties of production, his acquaintance with so many unsolved problems, and his frank intercourse with the engineer and scientist that explain the source of his knowledge of the essential and his careful attention to the technique of production. The inauguration after the War of his glass technology meetings started movements which brought out clearly the value of national coöperation in the interests of glass. During this era a research activity developed within the Deutsche Glastechnische Gesellschaft, which soon surpassed foreign work and benefited the home industry. Methodically, scientific methods found their way into glassworks. All of these attainments make his death extremely regretful. His place will be hard to fill. He had a far-reaching understanding of the anxiety and distress of our times, and the whole glass industry, far outside the border lines of Germany, is deploring the death of this man. We have become poorer in losing his experienced guidance.

On his sixtieth birthday anniversary which Max von Vopelius would have passed on July 27, a distinction was to have crowned his long activity in the service of glass technology.

"The President and Board of Trustees of the University of Hanover have granted to Dr. Max von Vopelius of Sulzbach (Saar) for his extraordinary advancement of the German Glass Industry by the founding and successful management of coöperative technological-scientific research, the title of Doctor of Engineering (Dr.-Ing. E.h.)."

The President of the University, Prof. L. Klein, notified Dr. Vopelius of this honor a few days before his death. Our Society is happy over this well-deserved reward of its first President, through which his activities have found due recognition.

On July of this year the Deutsche Glastechnische Gesellschaft was to have observed its tenth anniversary, but due to the illness of the President there was no celebration. The Board of Trustees unanimously passed the following resolution:

"The German Society of Glass Technology is looking back on this day of July 9, 1932, upon ten years of eventful history. Dr. Vopelius has had the presidency from the beginning of this Society. As one of its charter members he has been successful during these years in bringing about an exchange of ideas and experiences among firms and personalities who have been inspired to continue in international research. Through the activity of his co-workers under his wise and considerate leadership, the German Society of Glass Technology has gained a far-reaching influence within the glass industry which could hardly have been accomplished in any other way. The Board of Trustees, therefore has unanimously voted to appoint Max von Vopelius as Honorary President.

This honoring acknowledgment is expressed with full knowledge that the success of the Society is due above all else to his splendid personality which has always considered productive thought and knowledge as the foundation of our activity. We hope that, true to his prototype, devotional duty, faithfulness, and impartialism will continue to lift the Society in the years to come."

At the cremation in Saarbrücken, the Chairman of the Board, Dr. Maurach, delivered the following eulogy:

"In this hour of sadness and sorrow the German Society of Glass Technology and the Pyrometric Council of the German Glass Industry are sending their esteemed President the last farewell. As a token of their remembrance they are laying a wreath upon his bier. With Max von Vopelius a charter member of our Society has gone from us. He was more than a founder and had all his heart set toward the development and furthering of our efforts. Noble, kind, wise, and duty-bound, these were the characteristics attracting every one of his co-workers. It was a delight and satisfaction to be working under his leadership. This model of modesty and unselfishness was bound to meet with affection. It is impossible to clothe in words all the sentiments of esteem produced by a coöperative activity of twelve years. It is our duty of honor to express our deepest appreciation coming from our hearts, and so we must take leave from you, dear friend. Alas that it had to come at a time in which you should have harvested the fruits of your labor and found recognition. We shall keep and cherish your memory and go on to build and follow the way you have shown us until the day comes when we must follow you on the last mysterious trail. Peace be with you."

Deutsche Glastechnische Gesellschaft

Frankfort on the Main
July, 1932

CERAMIC SCHOOL NOTES

C. M. Dodd

C. M. Dodd has been appointed acting head of the Ceramic Department of the School of Mines and Metallurgy, University of Missouri, to succeed M. E. Holmes, who has been granted a year's leave of absence to accept the position of Dean of the New York State College of Ceramics of Alfred University. Professor Dodd is a graduate of Ohio State University and for the past five years has been Associate Professor of Ceramic Engineering at the School of Mines and Metallurgy. He has been active during this time with Dr. Holmes in numerous research projects affecting the ceramic industry, which projects will be carried on in the future insofar as his time will permit.

C. M. Dodd

Publications and Researches by C. M. Dodd

1. C. M. Dodd, G. A. Page, F. F. Netzeband, "Study of Dry-Press Process, *Brick Clay Rec.*, **78** [6], 322 (1931).
2. C. M. Dodd and M. E. Holmes, "A Study of the Effect of Grog on Pressure Transmission in Dry Pressing," *Jour. Amer. Ceram. Soc.*, **14** [12], 889 (1931).
3. C. M. Dodd, "The Effect of Various Factors on Pressure Transmission in Dry Pressing," Amer. Refract. Inst., *Tech. Bull.*, No. 33, March, 1932.

Researches on Dry Pressing (Directed)

4. The Effect of Grain Size and Grain Size Proportions on Pressure Transmission in Dry Pressing.
5. The Transmission of Pressure in the Dry Pressing of Typical Building Brick and Firebrick Mixes as Affected by the Variation in Grog Size.
6. A Study of Fired Properties of Dry Pressed Refractory Mixes Compounded on a Basis of Uniform Pressure Transmission.
7. The Effect of Evacuating Air from Mold Box on Pressure Transmission in Dry Pressing.
8. The Effect of Time of Dwell of Rams on Pressure Transmission in Dry Pressing.
9. The Effect of Rate of Ram Travel on Pressure Transmission in Dry Pressing.
10. The Size and Shape of Grain of Dry Press Mixes as Affected by Various Methods of Milling.
11. The Effect of Various Methods of Milling on Pressure Transmission in Dry Pressing.
12. Pressure Transmission as Affected by Aging of Dry Press Mixes.
13. Pressure Transmission in Dry Pressing of Fire Brick and Building Brick Mixes as Affected by Varying the Moisture Content.

Researches on White Ware

14. Cone Deformation Eutectics Using Sodium Chloride, Dolomite, and Aplite Rock.
15. Florida Kaolin as the Chief Clay Ingredient for a Sanitary Ware Casting Body.
16. Georgia Kaolin as the China Clay Constituent in Floor and Wall Tile Bodies.
17. Utilization of a Barium Calcium, Magnesium Eutectic Mixture as an Auxiliary Flux for a Feldspar, Flint, Georgia Kaolin Building Brick.

A. J. Paul

A. J. Paul has been added to the faculty of the Ceramic Department of the School of Mines and Metallurgy of the University of Missouri.

Mr. Paul is a graduate of the University of Illinois and has had some research experience in the Experiment Station there. For the past six years he has been ceramic engineer in charge of the physical testing of the Missouri Clay Testing and Research Laboratories. He has carried on extensive research work in connection with Dr. Holmes in refractories, and formerly had done work on various types of glazes. His research and testing experience make him especially qualified to enter into his new position on the faculty of the Ceramic Department.

A. J. PAUL

Publications and Researches by A. J. Paul

1. A. J. Paul assisted C. W. Parmelee and A. E. R. Westman in "An Investigation of Checker Brick for Carburetors," *Jour. Amer. Ceram. Soc.*, **9** [5], 290 (1926).

2. A. J. Paul, research associate to A. E. R. Westman in "Effect of Reducing Gases on the Transverse Strength of Fire Clay Brick," *ibid.*, **11** [8], 633 (1928).

3. A. J. Paul and M. E. Holmes, "The Effect of Various Addition Agents and Treatments on the Green Strength of Missouri Refractory Clays," *ibid.*, **12** [10], 676 (1929).

4. M. E. Holmes and A. J. Paul, "The Physical Properties of the Fineness Fractions of Slaked Semi-flint Clay," *ibid.*, **13** [7], 447 (1930).

5. M. E. Holmes and A. J. Paul, "Missouri Hard Flint Clay Fire Brick," *ibid.*, **14** [10], 755 (1931).

ANNUAL MEETING OHIO CERAMIC INDUSTRIES ASSOCIATION

October 14 and 15. Lord Hall, O. S. U., Columbus, Ohio

Friday Morning, General Meeting

10:00 A.M. Greetings, President C. H. Taylor. (15 min.)
10:15 A.M. Ceramic Research Work at the Ohio State University, Accomplishments and Plans, G. A. Bole. (30 min.)
Discussion, E. A. Hitchcock, Director, the Engineering Experiment Station (10 min.) and M. C. Booze, Vice-President, Chas. Taylor Sons Co. (5 min.)
11:00 A.M. Symposium on Metal Wear in Ceramic Manufacturing
(*a*) Metal Wear, E. W. Gillette, Battelle Memorial Institute. (20 min.)
(*b*) Report on Researches at Roseville, W. C. Rueckel, Research Engineer. (20 min.)
(*c*) The Metal Wear Problem as Seen by the Manufacturer of Metals, J. Mayer, Bethlehem Steel Co. (10 min.)
(*d*) What Metal Wear Means to the Ceramic Industry, C. E. Bales, Vice-President, Ironton Fire Brick Co. (10 min.)
(*e*) General Discussion. (10 min.)
12:10 P.M. Adjournment for Lunch.

Friday Afternoon, All Divisions except Whiteware Fabrication Problems

1:30 P.M. Evacuation in the Stiff-Mud Process, J. O. Everhart, Research Engineer. (20 min.)
Discussion, B. T. Bonnot, President, The Bonnot Company. (10 min.)
2:00 P.M. De-airing by Gas, G. A. Bole. (20 min.)
General Discussion. (10 min.)
2:30 P.M. Glazed Brick by the Dry Press Process, W. C. Rueckel, Research Engineer. (20 min.)
General Discussion. (10 min.)

3:00 P.M. Ceramics and the Program of Fabricated Houses.
(*a*) The Research Man's Viewpoint, G. A. Bole. (15 min.)
(*b*) The Manufacturer's Viewpoint, O. W. Renkert. (15 min.)
3:30 P.M. The Application of Ohio's New Tax Law to the Ceramic Industry, A. J. Kraus, Member Ohio State Tax Commission. (40 min.)
Discussion, J. O. Wilcox, Secretary, Alliance Clay Product Co. (10 min.); F. J. Grant, Secretary, S. A. Weller Co. (10 min.); Fred A. Newman, Valuation Engineer. (10 min.); General Discussion. (15 min.)
4:45 P.M. Adjournment.

Friday Afternoon, Whiteware Division

1:30 P.M. Future Researches for Whiteware, G. A. Bole. (10 min.)
1:40 P.M. Evacuation of Jigger Bodies, G. A. Loomis, Research Engineer. (20 min.)
2:00 P.M. Washing Georgia Kaolins (moving picture), Edgar Plastic Kaolin Co. (20 min.)
2:20 P.M. Cleaning Ohio Clays, M. C. Shaw, Research Engineer. (20 min.)
Discussion. (10 min.)
2:50 P.M. Possibilities in Special Fluxed Ceramic Bodies, A. S. Watts. (20 min.)
Discussion, V. J. Roehm, Sebring Pottery Co. (10 min.)
3:30 P.M. Members will go to Tax Discussion with other group.

Friday Evening

6:00 P.M. Dinner Meeting, Board of Trustees, Faculty Club.

Saturday Morning, General Meeting

10:15 A.M. Memorial to J. L. Murphy, W. Keith McAfee. (30 min.)
Annual Business Meeting.
10:45 A.M. Treasurer's Report, C. B. Harrop. (5 min.)
10:50 A.M. The Work of O. C. I. A. for the Coming Year, President-Elect. (20 min.)
11:10 A.M. Report of Public Relations Committee, H. D. Bruning, Chairman. (10 min.)
New Business.
Adjournment.
12:00 M. Buffet Lunch, Lord Hall.
2:00 P.M. Football.

NATIONAL PAVING BRICK ASSOCIATION MEETING

The annual meeting of the National Paving Brick Association will be held at Detroit, Mich., January 17 and 18, 1933, in connection with the Highway and Building Congress. This meeting is planned to be a most significant gathering. G. F. Schlesinger is Secretary of this Association.

STANDARDIZATION OF COLORS FOR PLUMBING FIXTURES

An example of the increasing interest in the standardization of colors for sanitary ware is the recent adoption of standard colors by the Toledo Scale Company as the regular colors for their products. These colors were selected by a Manufacturers' Advisory Committee on Colored Plumbing Fixtures in Coöperation with the National Bureau of Standards and are green, orchid, ivory, blue, light brown, and black. Except in the latter case, light shades of each color were selected, not only from a merchandising but also from a technical point of view so that they may be duplicated in all materials and under all manufacturing processes used for plumbing fixtures.

A Commercial Standards booklet No. CS 30–31 and entitled Colors for Sanitary Ware may be obtained from the Superintendent of Documents at Washington, D. C.[1] This booklet, besides reproducing the colors as accurately as possible on the printed page, sets forth the standard method of making color comparisons.

W. Keith McAfee, Box 623, New Castle, Pennsylvania, is Chairman and G. W. Wray, Bureau of Standards, Washington, D. C., is Secretary of the Standing Committee. They will be glad to give more detailed information to anyone interested. Through

[1] Price 20¢, stamps not accepted.

arrangements with one manufacturer, sample tile 2 by 4 inches are made up in vitreous china with glazes in the six standard colors, sent to the Bureau of Standards for comparison with the master set, and issued under serial number to anyone ordering a set and paying $1.50. Checks should be made payable to the Secretary of the Standing Committee with the understanding that all checks are to be turned over in full to the manufacturer of the samples.

A large number of these sets have been sent out and quite a few of them to associations and manufacturers not directly connected with plumbing fixtures, such as manufacturers of stoves, refrigerators, and wall coverings of various kinds. The project has helped in the problem of furnishing various bathroom and kitchen materials in colors that will harmonize. It is probable that from it will develop standardization of colors in other fields where the furnishing of different articles in color must be done by more than one manufacturer.

REPORT OF EXECUTIVE COMMITTEE MEETING OF BOARD OF TRUSTEES, AMERICAN CERAMIC SOCIETY

Held at Executive Offices, 2525 N. High Street, September 16, 1932

Members attending: E. P. Poste, W. K. McAfee, J. M. McKinley, A. Silverman, F. C. Flint, H. B. Henderson.

(1) Unfinished Business: The securing of an official representative in England, as decided upon at an Executive Committee Meeting held on April 8, has not been obtained.

(2) It was moved by Silverman and seconded by Henderson that the special committee of the Board of Trustees which was appointed at the February Meeting to consider advertising income should be dropped; that the recommendations of that committee be again referred to the Publications Committee, the latter Committee to formulate recommendations to be presented to the Board of Trustees.

(3) It was moved by Silverman and seconded by Flint that the Board suggest to the Committee on Publications that the name of the new publication shall be:

CERAMIC NEWS

Clays, Glass, and Enamels

(4) It was moved by McKinley and seconded by Henderson that the dues for 1933 be reduced to $10, this action to be submitted by letter ballot to members of the Board of Trustees, and, further, that the privilege of making special subscriptions shall be offered.

(5) It was moved by McAfee and seconded by Henderson that the income from dues of the Fellows shall be shown on the statement of assets and liabilities, and on income and expense statements, crediting the Fellows with the dues received and expenses incurred, the net showing as an asset in the SOCIETY's general statement, and as a liability credit to the Fellows.

(6) It was moved by McKinley and seconded by Flint that the SOCIETY

liquidate the Buckeye Building and Loan certificates of deposit, the money thus obtained to be used to meet the current year expenses. The Treasurer will give the Buckeye Building and Loan a legal notice by registered letter of the SOCIETY's desire to cash these certificates.

(7) It was moved by McAfee and seconded by McKinley to rescind the action of the Board of Trustees taken in 1929 regarding reinvestment of interest on invested assets, and that the interest received during the remainder of this year shall be applied to current expenses.

(8) It was moved by Flint and seconded by Silverman that the budget which was set up in April shall be continued for the remainder of the year. On the yearly basis this budget totals $32,800.

(9) Dr. Silverman presented the plans for the Annual Meeting next February, which program was approved with the single amendment that Tuesday afternoon shall be devoted to Division meetings, and that the meeting of the Fellows shall be scheduled for Wednesday, the Fellows meeting not to be given a public program listing.

(10) It was moved by McAfee and seconded by Flint that the registration fees shall be waived for students attending the Annual Meeting, provided such students are certified by their professors.

(11) It was moved by McAfee and seconded by Flint that the registration fee at the Annual Meeting shall be $2 uniformly for members, nonmembers, and for ladies.

(12) It was moved by McAfee and seconded by Flint that guests nominated by the SOCIETY or by the Local Committee shall receive a special invitation issued by the SOCIETY, and shall be registered without charge or registration fee.

(13) It was moved by McAfee and seconded by Henderson that the SOCIETY appropriate $500 to employ Mr. Grady to handle the publicity of the Annual Meeting, Dr. Silverman to make contacts with Mr. Grady, and A. W. Kimes to manage the coöperation between Grady and the Pittsburgh Chamber of Commerce Publicity Department.

(14) It was moved by McAfee and seconded by Henderson that the SOCIETY shall not employ Meeting reporters. Dr. Silverman volunteered to have stenographers from local offices available for taking a record of such business proceedings and discussions as shall be decided by the Division officers or officers of the SOCIETY.

(15) It was moved by Henderson and seconded by McKinley to unanimously approve resolutions prepared covering the extension of the activities of the SOCIETY to cover ceramic ware development and promotion, this resolution to be submitted to the members of the Board not attending to obtain their approval.

(16) It was moved by McKinley and seconded by McAfee that the 1933 Summer Meeting be approved, the Secretary with the Local Com-

mittee in Chicago to establish hotel headquarters and to collaborate with other societies meeting in Chicago during the week of June 25, 1933, known as "Engineers' Week," and to contact with the ceramic societies of other countries concerning the possibilities of their securing representatives to this Meeting.

(17) It was moved by McAfee and seconded by Flint that the Board of Trustees recommend to the Rules Committee for consideration a change in the Constitution, providing for one nominating committee with the personal representative of each and all of the Divisions, and of self-appointed nominating committees of an equal number to place in nomination candidates for president, vice-president, and treasurer.

In this connection it was unanimously agreed that the attention of the Nominating Committee should again be called to the desirability of making a constitutional provision for the electing of a president-elect, rather than a vice-president, the president-elect to automatically become president in the succeeding year.

(18) It was moved by McKinley and seconded by McAfee that it be recommended to the Committee on Research that it establish a scheme for correlating the research program of the schools, bureaus, and institutes so as to prevent as much as possible an overlapping and duplicating of researches.

In this connection it was recommended that the Committee on Research, in coöperation with the Editor, shall set up in the *Bulletin* a department for research news items of the schools, bureaus, and institutes.

(19) Without motion, it was recommended that the Committee on Research and the Committee on Education shall have specially stated sessions on the program at the Annual Meeting.

(20) Without motion, it was the unanimous opinion that the Committee on Geological Survey should be engaged in ascertaining the monies available in the different states for research of ceramic materials, and to seek opportunity for giving advice on the investigations to be undertaken.

(21) The question of providing separates of page proofs for sale was discussed, and it was moved by McKinley and seconded by Henderson that the SOCIETY shall not sell separate page proofs, but that any one wanting reprints of articles which have appeared in the *Journal* shall obtain reprints, or purchase the *Journal*.

(22) In summarizing a discussion of ceramic education activities, as developed in correspondence with Dr. Holmes of the New York State College of Ceramics, and Dr. Holmes' proposal that President Poste call a conference, it was the general opinion, without motion, that the Board should approve the closed session of the Fellows for purpose of discussing the qualifications needed and demanded of ceramic technologists, and should recommend that the Committee on Education shall develop a suggested

five-year ceramic curriculum, submitting the same for discussion by the members of the SOCIETY.

(23) The letter of Dean Steidle of Penn State College was read. It was moved by McKinley and seconded by Henderson that Secretary Purdy shall go to Penn State College, in response to Dean Steidel's invitation, and as a follow-up of the correspondence regarding the educational curricula and research activity program.

(24) The reports of the committees on Research, Data, Publications, and Standards were read. Without motion it was the general consensus that the President and Secretary should develop with these several committees the program of activities.

(25) In connection with the report of the Treasurer, the following statistics were presented:

Year		Profit and loss	Inventories	Salaries	Gross printing cost	Investments
1921	P	$ 117.18	$5059.20	$ 7447.09	$10568.33	$ 8700.00
1922	L	6886.50	5059.20	11074.48	15428.20	8700.00
1923	L	2875.88	5122.80	10110.57	16331.22	4700.00
1924	P	2929.12	5025.80	11313.78	15790.62	4700.00
1925	L	2057.67	5079.60	11645.53	18620.01	4700.00
1926	P	2156.66	3031.40	11643.28	13596.63	4700.00
1927	P	1958.84	2809.80	13786.65	16134.37	9861.00
1928	L	3929.54	2640.10	13908.62	18213.64	9861.00
1929	P	1226.79	2551.89	13769.30	20311.71	10280.02
1930	L	4750.37	2255.79	14759.75	22962.39	10719.84
1931	P	2078.03	1873.64	13905.00	20067.03	11175.79
1932 (8 mo.)	P	1535.77	1929.64	8195.75	7801.72	11410.01

STATEMENT AS OF DECEMBER 31

Year	Cash on hand	Accounts payable	Deferred income	Total liabilities
1921	$1762.51		$ 1651.19	$ 1651.19
1922	1910.64	$3000.00	4703.55	7703.55
1923	4376.66		9573.84	9573.84
1924	3529.00		6512.40	6512.40
1925	1945.27		6297.13	6297.13
1926	5322.87	2213.72	6334.50	8548.22
1927	2838.88		9686.99	9686.99
1928	3302.17		10007.95	10007.95
1929	1363.36		9528.95	9528.95
1930	2480.89	7747.22	8532.13	16279.35
1931	3372.28	6484.79	7217.21	13702.00
1932 (8 mo.)	763.29	965.37	8667.21	9632.58

JOURNAL COSTS FOR JANUARY–SEPTEMBER, 1932

	No. copies	No. pages	Type and presswork	Cuts	Postage	Total
January	2650	202	$1138.54	$180.28	$57.13	$1375.95
February	2650	194	1075.02	172.68	54.06	1301.76
March	2650	188	1085.26	90.51	58.96	1234.73
April	2500	172	938.46	71.23	42.13	1051.82
May	2150	172	927.76	89.73	60.26	1077.75
June	2150	138	706.11	93.43	51.33	850.87
July	2160	138	786.22	67.57	51.21	905.00
August	2150	134	747.65	124.45	46.79	918.89
September	2160	130	734.76	66.40	43.67	844.83
October						
November						
December						

NUMBER OF PAPERS PUBLISHED IN JOURNAL, 1925–1932

	No. papers through October	Total papers for year	No. pages through October	Total pages for year
1925	85	109	676	870
1926	82	95	700	896
1927	93	103	828	1028
1928	81*	95	794	934
1929	78	96	698	830
1930	77	104	786	976
1931	94†	109	794	938
1932	87		573	

* June issue had no papers. Standards report, pp. 331–534.

† Ten papers in Refractories Symposium. Similar Symposium was published in 1932 in *Bulletin*.

NUMBER OF ABSTRACTS THROUGH OCTOBER

	1927	1928	1929	1930	1931	1932
Abrasives	26	135	284	388	381	354
Art	161	234	313	483	364	415
Cement	245	271	215	215	369	150
Enamel	76	117	71	225	247	247
Glass	569	680	456	949	840	1099
Structural Clay	163	219	197	348	354	280
Refractories	343	333	333	508	568	521
Terra Cotta	21	50	42	109	64	87
White Wares	135	209	160	201	203	171
Equipment and Apparatus	140	261	160	560	453	346
Kilns and Fuels	179	385	199	195	548	327
Geology	96	128	161	236	262	193
Chemistry and Physics	330	398	295	485	428	449
General	261	302	352	412	602	271
Total	2645	3722	3238	5314	5683	4910

Balance Sheet

Statement of Assets and Liabilities

(August 31, 1932)

ASSETS

Cash in General Account at Banks	$ 458.29	
Revolving Fund	300.00	
Petty Cash	5.00	$ 763.29
Liberty Bonds (par $9700.00)	9861.00	
Treasury Certificates (par $400.00)	409.16	
Certificate of Deposit	1139.85	11410.01
Accounts Receivable (1931 and 1932)	1460.63	
Dues Receivable (estimate)	125.00	1585.63
Inventories: *Journals* (1922–1932)	1335.64	
Enamel Bibliography	134.00	
Transactions	460.00	1929.64
Office Equipment (less depreciation)		1977.96
Annual Meeting (deferred expense)		305.22
Accrued Interest		25.00
Total Assets		17996.75

LIABILITIES			
Accounts Payable (August printing)		918.89	
(Abstracters' fees)		46.48	
		965.37	
Deferred Income			
Dues, Corporation	$1557.64		
Dues, Personal	4928.11		
Dues, Fellow	229.17		
Divisions	515.22		
	7230.14		
Prepaid Curtis Survey Fund	37.00		
Unexpired Subscriptions	1400.07		
Total Deferred Income		8667.21	
Total Liabilities & Deferred Income			9632.58
Surplus August 31, 1932			8364.17

COMPARATIVE STATEMENT OF INCOME AND EXPENSES
8 Months, Ending August 31, 1932

				8 mo. (this year)	
INCOME	Last year	8 mo. (last year)	8 mo. (this year)	Publication	General
Dues, Corporation	$ 5650.28	$ 3793.52	$ 3115.27	$ 414.00	$2701.27
Dues, Personal	17973.84	12087.56	9856.23	5064.00	4792.23
Dues, Fellow	457.09	294.72	458.34		458.34
A. R. I.	1526.84	1017.48			
Divisions (net)	1292.38	888.75	1030.44		1030.44
	26900.43	18082.03	14460.28	5478.00	8982.28
Journals (Current)	4382.04	2827.82	2800.13	2800.13	
Journals (Old)	286.92	161.70	269.45	269.45	
	4668.96	2989.52	3069.58	3069.58	
Advertising (net)	10856.37	7321.79	5714.44	5714.44	
Miscellaneous Pub.	18.49	20.22	46.48	46.48	
Contributions	2035.00				
Annual Meeting	666.90	463.12			
Interest Earned	565.44	351.90	286.96		286.96
	14142.20	8157.03	6047.88	5760.92	286.96
Total Income	45711.59	29228.58	23577.74	14308.50	9269.24
EXPENSES					
Cost of Publication	19658.53	11864.68	8572.17	8572.17	
Abstracts	1926.90	1407.30	1006.11	1006.11	
Reprints	765.75	494.45	64.52	64.52	
Editor's Off. Exp.	1270.92	930.99	979.65	979.65	
	23622.10	14697.42	10622.45	10622.45	
Salaries	13905.00	9744.50	8195.75	4704.00	3491.75
Secy. Off. Exp.	1727.64	1158.96	693.54		693.54
President Off. Exp.			22.78		22.78
Postage	1352.45	868.35	658.39	250.00	408.39
Office Rental	1080.00	720.00	650.00	325.00	325.00

COMPARATIVE STATEMENT OF INCOME AND EXPENSES (*Continued*)

EXPENSES	Last year	8 mo. (last year)	8 mo. (this year)	8 mo. (this year) Publication	8 mo. (this year) General
Annual Meeting			610.43		610.43
Traveling	506.87	170.00	94.23		94.23
Committee Expense	10.32	10.32			
Miscellaneous			214.40		214.40
Century of Progress	554.43				
Depreciation	227.36	160.00	152.00	76.00	76.00
Bad Accounts	194.80	150.00	128.00	128.00	
Inventory Charged Off	452.59				
	20011.46	12982.13	11419.52	5483.00	5936.52
Total Expenses	43633.56	27679.55	22041.97	16105.45	5936.52
Gain or (Loss)	2078.03	1549.03	1535.77	(1796.95)	3332.72

(26) In connection with the report of the Committee on Publications, the statistics as shown on page 248 were presented.

It was surprising and gratifying that with the decrease in size of publication and with its consequent decrease in cost of publishing, the number of pages printed in the *Journal* through October and the number of Abstracts printed through October showed no decrease.

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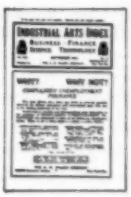

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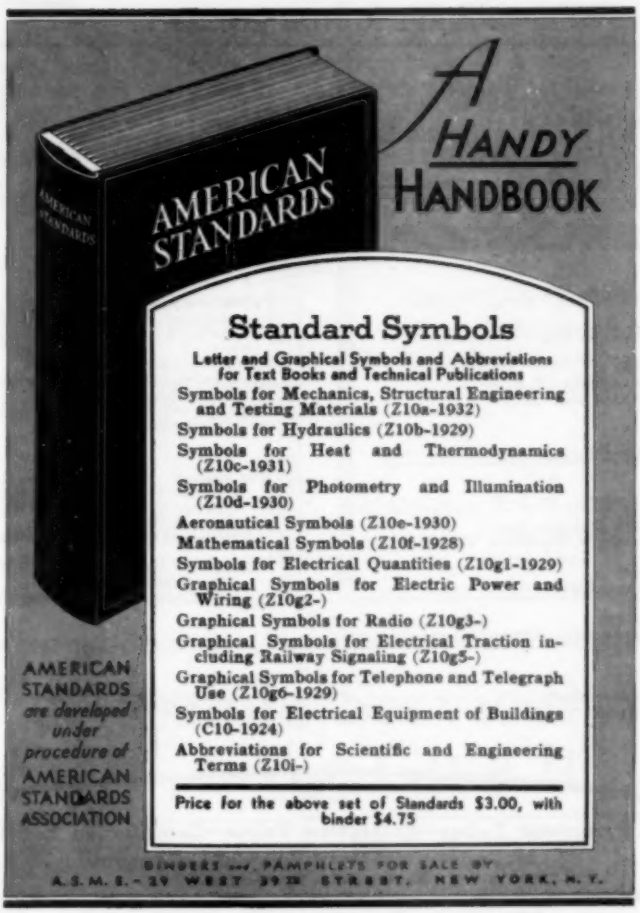
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